State of California
California Regional Water Quality Control Board, Los Angeles Region

Final Technical Staff Report

Evidence in support of an
Amendment to the
Water Quality Control Plan for the Coastal Watersheds
of Los Angeles and Ventura Counties

to Prohibit On-site Wastewater Disposal Systems
in the Malibu Civic Center Area

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway,* P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

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1. Purpose

Aquatic life in Malibu Lagoon is impaired by eutrophication resulting from excessive nitrogen loads. One of the sources of nitrogen loading is from discharges of wastewaters through on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area.

The purpose of this evaluation was to quantify cumulative nitrogen loads from OWDSs to Malibu Lagoon and compare the result with targets established through the TMDL for restoration of Malibu Lagoon.

2. Method

a. Malibu Civic Center Area Description and Data Collection

The City of Malibu does not provide regional sewage collection or treatment. Most wastewater generated in Malibu is treated by on-site wastewater disposal systems (OWDS) is the terminology used to describe wastewater discharged from both septic and advanced treatment systems (defined as more advanced than primary treatment, i.e. secondary and tertiary treatment with disinfection). The Malibu Civic Center area for this evaluation corresponds to the lower two miles of the Malibu Creek watershed, which discharges to the Malibu Lagoon and the ocean, and was divided into 5 sectors as shown in Map 1. The Malibu Civic Center area includes the Malibu Valley, Winter Canyon, and the surrounding hills and the beaches located immediately north and south of the Lagoon[1].

The main commercial area in the Malibu Valley has historically been referred to as the Malibu Civic Center area. Both Los Angeles County and the City of Malibu have administrative

[1] The area subject to the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1). The area was defined using topographic features and drainage patterns, and encompasses the hydrologic areas of Malibu Valley (also referred to as the lower Malibu Creek watershed), Winter Canyon, and adjacent coastal strips including Amarillo Beach, Malibu Beach, Malibu Lagoon, and Malibu Lagoon Beach (aka Surfrider Beach, including First, Second, and Third Points at Surfrider). For more discussion on the prohibition boundaries defining the Malibu Civic Center area, refer to the Technical Staff Report Overview and the Environmental Staff Report.

offices there. Commercial development is concentrated along Pacific Coast Highway, Malibu Road, Civic Center Way, and Cross Creek Road located adjacent to Malibu Creek just above the Malibu Lagoon.

Malibu Civic Center area has high groundwater and is also subject to flooding and tidal fluctuations. Shallow groundwater located in the Cross Creek area closest to Malibu Lagoon rises and drops in response to daily tides (Figure 1) and provides direct evidence of communication with Malibu Lagoon and the ocean. Each Waste Discharge Requirements (WDR) includes a monitoring and reporting program that requires quarterly submission of self-monitoring data. These data include mass loading from wastewater discharged at commercial properties located in the Malibu Civic Center area. The subsequent evaluation of such data incorporates information from monitoring reports submitted to the Regional Board from the 4th quarter 2004 to the 2nd quarter 2009. The time interval for data inclusion is post release of the Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", in 2004 (2004 Stone Report).

This evaluation of nitrogen loading from the subsurface discharge of sewage incorporates information from Regional Board records. WDRs have been issued to most of the larger commercial dischargers in the area; and for these sites, a Monitoring and Reporting Program (MRP) is issued with every permit. For smaller businesses and private residents, staff have used inventory listed in 2004 Stone Report.

Staff identified all of the commercial and residential properties located in the Malibu Civic Center area. The inventory consists of 392 residential properties and 38 commercial properties. When it was available, real data on wastewater volumes and total nitrogen (TN) concentrations from self-monitoring reports were used for this evaluation. When actual data were not available, conservative assumptions, based on information from published literature, were used to calculate nitrogen mass loading from all wastewater discharged in the Malibu Civic Center area. Results from the summation of the wastewater TN load are used to model attenuation of the nitrogen load as it moves from the point of discharge to groundwater and from groundwater as it flows to the Lagoon.

Commercial Sites - Several sources were used for the inventory of commercial properties located in the Malibu Civic Center area. The Regional Board's databases for permitted and un-permitted commercial facilities were the primary sources of information (Table 1). Other sources of information were the 2004 Stone Report, the City of Malibu, and the (2002) Malibu Survey by S. Groner & Associates. Wastewater discharge volumes from commercial properties located in the Malibu Civic Center area were extracted from the self- monitoring reports submitted for those facilities which are permitted. For the un-permitted commercial properties, additional information regarding business activities, population served, and the OWTS was utilized to estimate discharge volumes and wastewater strength.

Residential Sites – An inventory of residential properties located in the Malibu Civic Center area was listed in the 2004 Stone Report and used for its assessment of nitrogen loads contributed by residential properties in the Malibu Civic Center area[2]. This inventory was originally extracted from Los Angeles County's Assessor's data of 2002. Information is posted in the Assessor's web-page by Assessor Identification Number (AIN). The number of bedrooms and bathrooms at each residence was used to estimate the wastewater discharge volume for each home. Calculations for the total nitrogen load discharged at residential property in the Malibu Civic Center area used the estimated wastewater discharge volumes. The residential property inventory sorted by sector location is listed in Table 2.

Geographic Sectors – Earlier evaluations approached the assessment of nitrogen loading by estimating the percentage of the groundwater flow from the entire lower Malibu Creek watershed, which discharges to the Lagoon versus the Pacific Ocean. Staff evaluation of nitrogen loading to the Lagoon used a different approach. All sectors of the entire watershed do not have an equal flow contribution to impairment of the Lagoon. Therefore, staff divided the Malibu Civic Center area into geographic sectors to evaluate groundwater flow and nitrogen load contribution to evaluate impairment of the Lagoon from OWDS discharges. Initially, the area surrounding Malibu Lagoon was divided into five geographic sectors on the basis of surface topography (Map 1). Surface geographic features marking boundaries for the sectors are the gently sloping Valley floor, Malibu Creek, Pacific Coast Highway (PCH), and the Pacific Ocean. After considering flow gradients, subsurface hydrologic, and geologic conditions, two of the sectors were further divided on the basis of estimated flow contribution to the Lagoon. Each sector has a unique flow contribution to the Lagoon.

b. Total Nitrogen Loading from On-site Wastewater Treatment Systems

Slightly different approaches had to be taken to calculate total nitrogen loads from wastewater discharged at commercial and residential sites. Because the Regional Board issues permits or WDRs for wastewater discharges from commercial sites, there has been much more information on file for commercial properties. Historically, permitting of residential wastewater discharges has been delegated to local agencies.

i. Commercial Wastewater

Staff calculated the nitrogen loading from the commercial facilities dividing the commercial facilities into three groups. One group includes permitted facilities with advanced wastewater treatment, effluent volume limits, and discharge volume limits. At these permitted facilities, a Discharger is required to measure wastewater volumes, total nitrogen concentrations at "end of pipe," and submit this information to the Regional Board per the MRP issued with the WDR. Staff was able to use actual data from these sites to calculate the nitrogen loads. The second group includes smaller permitted commercial facilities where monitoring of wastewater discharge volume is required, but not effluent monitoring, because these facilities discharge domestic-type wastewater. In these cases, staff estimated nitrogen loading by using the provided flow information and published information on total nitrogen concentrations for domestic wastewater from similar types of businesses. The third group includes all un-permitted commercial facilities. In these cases, staff conducted drive-by inspections and

[2] Stone Environmental, Inc., "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California," 2004.

collected information from several other sources regarding the OWTS, the business activity, and the population served in order to estimate wastewater flow, nitrogen concentration, and nitrogen loading from these commercial sites. A list of commercial facilities is provided (See Table 1).

General Characterization of Wastewater Strength

Biochemical oxygen demand (BOD) - BOD is the measurement of the rate of oxygen uptake used by microorganisms to oxidize or consume organic matter over a specified period. The 5-day BOD (BOD_5, 5-day, 20^oC) value is a widely used single strength measure of wastewater and/or polluted surface water containing degradable wastes. Thereafter, in this technical memorandum the term BOD refers to BOD_5, 5-day, 20^oC; although BOD_5 does not measure nitrification, staff found there was a consistant TN/BOD ratio in the wastewater from the mixed-use shopping centers in Malibu (see Table 4 which summarizes 106 septic tank samples). The strength of wastewater is commonly expressed in terms of BOD, suspended solids, and chemical oxygen demand (COD). COD is commonly used to measure the amount of oxygen consumed under specific conditions in the oxidation of organic and inorganic material in both sewage and industrial waste. Both BOD and COD greatly impact the amount of dissolved oxygen in receiving water and determine the waste assimilative capacity of that surface water, an example being the Malibu Lagoon.

There are several chemical, physical, and biological parameters which provide information on water quality and organic pollution. These parameters are total and fecal coliform density, pH, nitrite, nitrate, Kjeldahl nitrogen which includes, ammonia nitrogen, and organic nitrogen, phosphates, chlorides, turbidity, suspended solids, temperature, grease fats and oils. BOD is commonly used for the characterization of domestic wastewater and the sizing and design of wastewater treatment systems. In this study, BOD is used to estimate total nitrogen when total nitrogen data is unavailable.

Total Nitrogen Concentration Milligrams per Liter (mg/L) **-** Total nitrogen concentration in milligrams per liter (mg/L) measured at “end of pipe” (e.o.p.) was used for load calculations when this information was available. Staff also used previous analyses of samples taken directly from the septic tanks. There is considerable information in Regional Board files on the septic tank composition for commercial sites in the Malibu Civic Center area.

Where neither e.o.p nor septic tank effluent analyses was available, staff based the estimation of total nitrogen on typical total nitrogen (TN) concentrations seen in the published literature on domestic wastewater composition. BOD values for commercial wastewater are more widely available than total nitrogen values and total nitrogen can be estimated as a proportion of BOD. Most wastewater engineering textbooks have tables showing the concentration of various elements in typical untreated domestic wastewater. Review of this information yields a percentage proportion or TN/BOD ratio[3] of 21%

[3] Table 4-14, on page 181 in Crites and Tchobanoglous, “Small and Decentralized Wastewater Management Systems,” 1998.

between total nitrogen (TN) and BOD. Another widely used textbook on wastewater engineering shows TN/BOD ratios ranging from 18% to 21%.[4] An average TN/BOD ratio of 20% was used to estimate the total nitrogen load at selected commercial sites.
In the nitrogen load spreadsheet, either a total nitrogen value from "end of pipe" or an estimated total nitrogen value derived from the TN/BOD ratio in the above tables was used for the nitrogen load spreadsheet, where no "end of pipe" total nitrogen value was available.

Assumptions Made for Commercial Nitrogen Loading Calculations

Most of the larger commercial wastewater discharges have been permitted. There are 38 commercial sites located in the Malibu Civic Center area, 25 of which have been permitted. Total nitrogen concentrations measured at "end of pipe" and wastewater discharges volumes are available and were used for nitrogen loading calculations for these sites. When wastewater effluent analysis was not available, estimation of the total nitrogen load (TN) was based on published information for similar businesses or typical nitrogen concentrations for domestic wastewater. The total nitrogen load spreadsheet developed as Table 1 has two key assumptions: 1) BOD value based on the type of business, and 2) a total nitrogen load based on the average TN/BOD ratio found in the above wideky used college textbooks on wastewater treatment such as Metcalf and Eddy (1991 and 2003). The volume of wastewater discharged is known for most commercial properties in the Malibu Civic Center area, but an estimate of wastewater volume had to be made for 10 of the smaller unpermitted commercial sites. Basic assumptions are listed below:

<u>TN/BOD Ratio</u> - Most of the larger commercial discharges in the Malibu Civic Center area, such as Malibu Colony Plaza, Malibu Creek Plaza, and the three Malibu Country Mart shopping centers, were permitted by the Regional Water Quality Control Board, and as a result staff have analysis of septic tank samples, or "end of pipe" effluent where advanced OWTS have been installed.

For commercial dischargers such as small offices where staff have no data, staff choose a low BOD of 220 mg/L, and estimated the TN to be 40 mg/L.

For wastewater generated by commercial facilities, such as schools, mid-range to high-range effluent strength and nitrogen concentrations were assumed. Performance of the OWDS depends primarily on the soil profile and groundwater separation. Footnotes were added to Table 3 to indicate additional critical factors such as failed leachfields or the use of seepage pits for disposal which impact estimated total nitrogen reducing TN values ranging from 75 mg/L to 45 mg/L for these sites.

<u>Flow Rate</u> - For the purpose of calculating nutrient load due to wastewater discharges from OWDS, staff have used actual flow data from monitoring reports for commercial facilities permitted by the Regional Water Quality Control Board. As stated previously, the septic discharge volume or flows for residential and smaller un-permitted commercial properties

[4] Table 3-16, page 109, Metcalf & Eddy, Inc. "Wastewater Engineering Treatment, Disposal and Reuse," 3rd Edition, 1991.

were estimated. For the residential properties, the flow estimate was based on the number of bedrooms.

Some of the smaller commercial properties remain unpermitted because the City of Malibu agreed to assume responsibility for any non-food preparation commercial properties discharging less than 2,000 gpd. For most of the smaller unpermitted commercial properties under the jurisdiction of the City of Malibu, Regional Board staff assumed a flow of 400 gpd. Many of the smaller commercial properties were not included in previous Malibu inventories and surveys.

2001 Tetra Tech[5] and 2003 U.S. Environmental Protection Agency [6] studies on Total Mass Daily Loads generated in the Malibu Civic Center area used total commercial wastewater flow of 75,000 gallons per day (gpd). Since 2001, the inventory of commercial properties located in the City of Malibu has increased. Current total wastewater volume generated by the commercial properties located in the Malibu Civic Center area is 127,241 gpd. This reflects a greater than 100% increase in the wastewater discharge volume estimated for commercial properties in the Malibu Civic Center area made by in earlier nitrogen loading studies, e.g. 2004 Stone Report, 2005 Questa Report, and 2001 Tetra Tech Report.

The Regional Board staff estimate of the wastewater discharge volume associated with residential OWDS located in the Malibu Civic Center area is 139,300 gpd. This volume was, virtually identical to the residential volume in the 2004 Stone Report. Staff estimation of the commercial wastewater discharge volume is greater than commercial discharge volume estimate of 62,166 gpd in the 2004 Stone Report. This Regional Board staff assessment of total nitrogen load does not include non-septic or OWDS nitrogen load contributions.[7]

Formula Used for Calculation of Commercial Nitrogen Loading

Calculations of nitrogen loading from commercial properties were made with the equation (4-4, page 193) shown below.[8]

Mass Load, lb/d = (concentration, mg/L)(flow rate Mgal/d) [(8.345* lb/Mgal x mg/L)]

The above formula has two variables, including: 1) concentration of total nitrogen (TN) in milligrams per liter (mg/L), and 2) flow rate in million gallons per day (Mgal/d). (8.345* is a unit conversion factor)

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[5] Tetra Tech, Inc., 2001, "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.
[6] U.S. Environmental Protection Agency, "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.
[7] HRL industrial wastewater nitrogen load of .31 lbs/d; TN load from use of treated wastewater for landscape irrigation on Pepperdine University Campus; TN load carried by Malibu Creek from upper watershed; and the TN load from the Malibu Colony private golf course.
[8] Page 196, Crites and Tchobanoglous, "Small and Decentralized Wastewater Management Systems," 1998.

For the permitted commercial properties, staff used reported average wastewater discharge volumes and total nitrogen values compiled from quarterly monitoring reports for the loading calculations. This evaluation includes more "end of pipe" nitrogen concentrations for our total nitrogen load calculations. Using reported or estimated wastewater discharge volumes and total nitrogen concentrations, wastewater flow was multiplied by the nitrogen concentration to obtain the nitrogen loading rate.

For unpermitted commercial facilities, flow and nitrogen concentration in the wastewater discharge for each business was estimated based on the information searched about the business activities and number of people working or type of business.

ii. Residential Wastewater

A different approach was needed to determine nitrogen mass loading from residential areas. Both discharge volume and nitrogen concentration of the residential domestic wastewater had to be estimated. Wastewater flow was based on the total number of houses and the bedrooms and bathrooms in each house. Residential property located in the Malibu Civic Center area was listed by Los Angeles County's Assessor Identification Number (AIN) from 2004 Stone Report. With AIN numbers, staff found the address and the number of rooms and baths for each residence posted on the County Assessor's web-page.

Staff assigned houses per their address into the five sectors. Addresses were viewed with aerial photo location guides to insure their section location. Once houses were grouped by sector, the total flow from each sector was calculated by multiplying the total number of homes by 100 gpd produced per bedroom. The next step was to estimate the nitrogen concentration in the domestic wastewater. Staff consulted published literature on wastewater to estimate the nitrogen load. The research indicated that typical untreated domestic wastewater has a range of total nitrogen concentrations. Review of standard engineering literature found nitrogen concentrations of 20 mg/L, 40 mg/L and 85 mg/L, defining domestic wastewater strength[9] as weak, medium or strong. Staff chose a nitrogen concentration of 45 mg/L for calculating the nitrogen load from residential sites. The residential property inventory was sorted by sector location is listed in Table 2.

Assumptions for Residential Flow and Total Nitrogen Concentration

Assumptions made to determine the flow and nitrogen loading from each residence in the absence of wastewater meter and sampling and analytic data of each discharge are listed below.

<u>100 Gallons per Day per Bedroom</u> - Regional Board staff estimated the flow by making the assumption that at least there is one user per bedroom (personal private bedroom/bathroom combination) at home with a total water use per person of 100 gallons per day. The 100

[9]Table 3-16, page 109, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition , 1991

gallons per person is widely used number for design and estimation purpose of wastewater flow[10].

<u>45 mg/L for Domestic Wastewater</u> - The nitrogen level in the domestic wastewater depends on the wastewater strength or organic load type discharged to OWDS. Waste strength is determined by considering food preparation practices, type of food prepared and consumed (e.g. high protein foods have higher nitrogen content), the use of garbage disposal units, left-over food handling and disposal practices, etc. The sewage generated by affluent neighborhoods has higher strength, measured by BOD and higher total nitrogen concentrations. Domestic wastewater with levels of TN as high as 80 mg/L, are associated with residential affluence.[11] Considering affluence and other factors, Regional Board staff selected a septic tank influent value of 60 mg/L of nitrogen, a concentration exactly mid-range of nitrogen concentration values assigned to untreated domestic wastewater, which ranges between low (20 mg/L) medium (40 mg/L) and high (85 mg/L) strength.

Another source of nitrogen reduction occurs within a septic tank, especially when the septic tank is oversized for the wastewater volume and the retention time is several days. This nitrogen load reduction is called "in-tank denitrification" and it can reduce a large percentage of total nitrogen from the effluent. Also, ammonia nitrogen can be incorporated into microbial or plant biomass in the septic tank systems as well as in the subsurface effluent disposal zone given certain environmental conditions. In general, this is not considered a major mechanism for nitrogen removal from septic tanks, but the total nitrogen concentration in residential effluent in the Malibu Civic Center area was further reduced from 60 mg/L to 45 mg/L before calculating the total nitrogen load from residential OWTS. The value of 45 mg/L TN concentration reflects an in-tank reduction of TN with equivalent to the soil reduction values given in Table 3-19, USEPA (2002) Onsite Wastewater Treatment System Manual treatment and removal. Table 14-7,[12] indicates that the total nitrogen concentration in the septic tank effluent ranges from 25 mg/L to 60 mg/L. A nitrogen concentration of 45 mg/L for OWDS treated wastewater is mid-range of typical domestic wastewater strengths.

Formula Used for Calculation of Residential Nitrogen Loading

The same basic formula is used to calculate mass load of nitrogen from residential wastewater, but with no data or metering of the discharge volume, residential flow volume was estimated using, the number of bathrooms is multiplied by 100 gpd. Flow volume is converted to million gallons per day by multiplying (10^{-6}). Nitrogen load is calculated by multiplying flow volume by the effluent nitrogen concentration of 45 mg/L and unit conversion values. The formula shown below shows the complete calculations described:

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[10] Table 2-9, page 27, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition , 1991

[11] Rich Stowell, personal communication, Notes from State Board Training Academy training course "Wastewater Engineering 2, Volume 1, The Advanced Class," 2009.

[12] Table 14-7, page 1040, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

$$\text{Mass Load, lb/day} = \frac{\text{No. of}}{\text{bathrooms}} \times 100\text{gpd} \times 3.785\frac{\text{L}}{\text{gal}} \times \frac{\text{Total}}{\text{Nitrogen}} \frac{\text{mg}}{\text{L}} \times 2.205 \times 10^{-6} \frac{\text{lb}}{\text{mg}}$$

iii. Summary of Total Nitrogen Loading from Commercial and Residential Sites

Staff's inventory of commercial wastewater flows in the Malibu Civic Center area consists of 25 permitted sites and 13 unpermitted sites. The total wastewater discharge volume released from these commercial properties is 127,241 gallons per day (gpd). The total nitrogen load carried to groundwater by these wastewater discharges is 42.1 lbs/day or 15,368 lbs/year.

Total residential flow is 139,300 gpd and the total nitrogen load from residential sites is 52.3 lbs/day or 19,093 lbs/year.

Total nitrogen loading from commercial and residential wastewater is summarized in Table 1. Total flow of 266,541 gpd and total nitrogen loading of 94.4 lbs/day are used for both spreadsheet and numerical models to estimate the mass loading to Malibu Lagoon.

c. Modeling to Estimate Nitrogen Load to Malibu Lagoon

i. Numerical Model

Using an updated total nitrogen release of 94.4 lbs/d in the numerical fate and transport model, the estimation of wastewater derived nitrogen load transported by groundwater flow to the Lagoon is 30.2 lbs/day. When the estimated total nitrogen load is greater, the numerical model indicates load to the Lagoon is greater. Details of the numerical modeling approach to estimate mass loading to the Lagoon, using updated total nitrogen load, and older load assessments were prepared by Dr. C.P. Lai, and are appended to this Technical Memorandum #4 as Attachment 4-1.

ii. Spreadsheet Model by Flow Reduction via Geographic Sectors and Soil Reduction

Flow Reduction Factor

Flow portioning reduces the TN load reaching the Lagoon. Factors governing flow contribution include: wastewater discharge locations, surface topography, and groundwater contours, which control the direction of groundwater flow. Different proportions of the total wastewater discharged in each reach the Lagoon.

<u>Sector I</u> - consists of the Winter Canyon drainage and the bedrock highlands that extend above the western side of the Malibu Valley. Sector 1 corresponds to the Winter Canyon and West Alluvium areas described in the 2004 Stone Report. Exclusive of Pepperdine University, there are nine commercial wastewater discharges located in this sector. The wastewater discharged from the commercial facilities in Sector 1 is a mixture of treated and only primary treated wastewater and the total discharge volume is 52,397 gpd. There are 61 homes in Sector 1, discharging an estimated 19,800 gpd of wastewater.

The highland area is bisected by Malibu Canyon Road and includes 61 homes and a portion of the Pepperdine University campus. Winter Canyon is not eroded to the depth of the Malibu Valley and thickness of the alluvium is less. Sector I is subdivided into two sub-sectors with significant differences in contribution to the Lagoon. The greatest volume of wastewater from Sector I is discharged in the Winter Canyon drainage, but the Winter Canyon load is assumed to have a small contribution to Malibu Lagoon via tidal inflow (USEPA, 2003, p34, estimated as much as 5 percent of nitrogen is from tidal inflow). Most of the wastewater discharged in Winter Canyon is assumed to discharge between Amarillo Beach and Malibu Beach.

Sector I is divided into the Winter Canyon drainage and drainage from highland area southeast toward Malibu Valley. The division is based on topography. Wastewater in this sub-sector is discharged from mostly single family homes, private schools, nurseries, and the HRL facility. Flow is directed by topography southeast to the western edge of Malibu Valley and east toward Malibu Creek Canyon.

Regional Board staff assumed that the maximum contribution to the Lagoon from this sub-sector is 45% of the total flow. The fractured bedrock highlands outside of the Winter Canyon drainage have a thin veneer of soil. It has been assumed in some previous studies that all wastewater from septic discharges to this highland area flows into the alluvial sediments on the west-side of Malibu Valley. Where flow through the relatively impermeable alluvium is slow and travel times to the Lagoon of 30 years to 50 years. A portion of the wastewater flow from this highland sub-sector does enter the alluvium, as evidenced by the relatively high nitrogen concentrations and high bacteria found in the monitoring wells located near the Valley walls (e.g. monitoring wells located at the Mira Mar Properties on Stuart Ranch Road and behind the County Administration Center on Civic Center Way). Monitoring wells used for the Stone risk assessment study were all located in the alluvium of the Malibu Valley and none of the groundwater table contours extend to the bedrock highlands, which represent over 50% of the Malibu Civic Center area.

Groundwater takes the path of least resistance. It can be logically assumed that some portion of the septic wastewater will percolate down into the fractured bedrock, until it reaches the water table. Low permeability sediments are not recharged at high rates; flow is restricted. There should be sufficient hydrostatic head for groundwater flow through the highly fractured bedrock underlying the Valley. Unconfined, this groundwater will rise to potentiometric surface.

Malibu Water Company records and geologic reports[13] indicate that the deep and shallow alluvial aquifers in the Malibu Valley are recharged by groundwater in the fractured bedrock exposed in the surrounding highlands. All unconfined groundwater in the Malibu Civic Center area rises to the same potentiometric surface, a surface that slopes from the bedrock highlands to sea level. Groundwater in the bedrock highlands derived from

[13] Old records for the Malibu Water Company, owned and operated by the Adamson Family, are kept in storage at Mariposa Land Company, LLC, offices on Cross Creek Rd.

rainfall, infiltration from septic discharges, and irrigation preferentially would not flow into relatively impermeable alluvial layers of silt and clay when high permeability sands, gravels, and fractured bedrock underlying the Malibu Valley provide a relative super highway for groundwater flow. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. There are no confining layers in this relatively coarse alluvium. These sediments have high conductivities and travel times of 400 feet a day (ft/d).

Sector II – Sector II consists of area along the east side of Malibu Creek including the residential area surrounding Serra Retreat and the surrounding highlands, which drain to this area. In the Stone Environmental report, Sector II corresponds to the Malibu Tributary, Serra Retreat, North Alluvium, and East Alluvium areas. There is only one commercial facility located in Sector II; that is Serra Retreat with a relatively low wastewater discharge of 428 gpd. There are 83 homes located in this sector with an estimated wastewater discharge volume of 30,900 gpd.

Percolate from septic systems following topography flows toward Malibu Creek. Most of Malibu Water Company's water supply wells were located in this area. It was implied in previous nitrogen load studies that flow from the wastewater discharged into the thin alluvium draped over the bedrock highlands in this sector was confined to this thin soil layer until it reaches the alluvial sediments in the Valley. Alluvium adjacent to Malibu Creek on the east-side of Malibu Valley has very high conductivities, 400 ft/d, and travel times of less than one year for the alluvium in this area of the Malibu Valley were estimated in the (2004) Stone report[11]. Regional Board staff estimated that as much as 95% of the total wastewater flow from this sector reaches the Lagoon.

Sector III – Sector III consists of the relatively flat, gently sloping floor of Malibu Valley located north of Pacific Coast Highway. Sector III is generally described as the Malibu Civic Center area and most of the commercial development is located here. Many of these commercial facilities are located close to Malibu Creek and the Lagoon where the alluvial sediments have high conductivity. Travel time to Malibu Creek and the Lagoon for wastewater discharged in this area can be less than one day. Staff estimates 95% of the wastewater flow from this area reaches Malibu Creek and Lagoon. An exception to this high percentage of total flow is the wastewater discharged from two commercial properties located near the western edge of Malibu Valley. The (2004) Stone report found travel times to the Lagoon from this area can be as much as 50 years[14]. The Racquet Club and Miramar Properties are located in this area. It is estimated that only 20% of the wastewater discharged at these two sites reaches the Lagoon.

Only two homes with an estimated wastewater of 800 gpd are located in Sector III. There are 16 commercial facilities located in Sector III. An estimated 51,598 gpd, consisting of wastewater from both septic and advanced wastewater treatment systems, is discharged in Sector III.

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[14] Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", 2004.

Sector IV – Sector IV consists of commercial facilities located south of Pacific Coast Highway along Malibu Road and 223 homes located in Malibu Colony and Amarillo Beach. All of the wastewater generated at Malibu Colony Plaza, which encompasses all of the commercial facilities located between Malibu Road and Pacific Coast Highway, is pumped under Pacific Coast Highway to Winter Canyon for treatment and disposal and assigned to Sector 1. Most of the wastewater from commercial development in this sector is collected and treated in Winter Canyon. Only five commercial properties located in Sector IV are not connected to the Malibu Colony Plaza wastewater collection system. The collective, wastewater discharge from these commercial properties is only 2,490 gpd.

There are 223 homes located in Sector IV. Wastewater, from the five commercial properties and most of the homes (150), discharges directly to the ocean and beaches north of Malibu Lagoon. A portion of the nutrient and bacteria load discharged to the beach can be transported with sediments toward the Lagoon by the prevailing long-shore movement of northwest to southeast. Once transported toward the Lagoon, it can enter the Lagoon through tidal inflow. The U.S. Environmental Protection Agency estimated that tidal inflow contributed only 1% of the nutrient load in Malibu Lagoon. Staff estimates that 1% of the 52,300 gpd of wastewater discharged in the main area of Sector IV could reach the Lagoon, but acknowledges the proportion could be much smaller.

There are alluvial sediments, estuary sediments, and beach sand beneath Sector IV. Both high and low permeability are found in this mixture of sand, silt and clay. Generally, nutrient removal by soil bacterial action would be high, but it is not because there is little separation between septic discharges and groundwater. Much of this coastal area has little elevation above sea level.

Sector IV has a sub-sector located near the Lagoon and subject to Lagoon tidal fluctuations. A collective wastewater flow of 25,900 gpd from 73 homes is assigned to the near Lagoon sub-sector. It is estimated that nearly 45% of the 25,900 gpd of the wastewater discharged in this sub-sector reaches the Lagoon.

Sector V – Sector V consists of a narrow coastal corridor located east of Malibu Lagoon and adjacent to Pacific Coast Highway and the Pacific Ocean. Sector V is smallest section and contributes little groundwater flow to the Malibu Lagoon. The topography of the area directs groundwater flow to the ocean. This area is described as the East Shore in the 2004 Stone Report. Bacteria and nitrogen from wastewater discharged directly to the ocean pollute the public beaches in this sector. Nitrogen and bacteria discharged to the beaches south of the Lagoon can be transported toward the Lagoon during short intervals when there is a southern swell, usually in the summer and early fall months when storm center highs are located to the south off the coast of Baja California. At such times, coastal long shore transport can reverse direction.

There are nine commercial facilities and 23 homes located in Sector V. The commercial wastewater discharge volume is estimated at 20,328 gpd. Three of the commercial facilities have advanced OWTS and thus, this volume is a mixture of septic and more treated wastewater. The estimated residential wastewater discharge volume from the 23 homes located in Sector V is 9,600 gpd.

Staff estimates a very small proportion of the wastewater discharged in Sector V, approximately 1% of the total flow, has a chance of being transported northward toward the Lagoon where it could be carried by tidal inflow.

Soil Treatment Reduction Factor

Soil Nitrogen Load Reduction Factor for Commercial Sites - Given sufficient separation between the point of wastewater effluent discharge and groundwater, soil bacteria can remove significant amounts of nitrogen. This soil bacteria activity is called "soil treatment". Another factor that influences the removal of nitrogen in the wastewater disposal zone is the soil composition and permeability. This characteristic of the soil is the reason that most permitting agencies require soil percolation testing. If the percolation is too fast (e.g. clean, coarse grained, uniform sand), wastewater flow through the near surface oxygenated zone does not allow time for nitrogen removal by soil bacteria. If the percolation rate is too slow (e.g. very fine soils with high clay content), subsurface disposal of wastewater may not be possible. Table 3 contains information on the depth to groundwater and soil type was utilized to estimate total nitrogen load reduction factors by "soil treatment" ranged from 0% to 20% (modified from Table 3-19 on page 3-29, USEPA, 2002, to account for leachfield failure or seepage pit disposal).

No Soil Treatment Factor for Residential Sites - Permitting of OWDS for residential property is delegated to local agencies, and staff do not have information on site-specific conditions needed to make an estimate of "soil treatment" or load reduction factor. Therefore, a nitrogen load reduction factor could not be applied to the nitrogen load estimated for residences located in the Malibu Civic Center area. It is known that many of the Malibu Colony residences lack adequate separation from groundwater. In addition, many residences in the highland sectors of the Malibu Civic Center area use seepage pits rather than leachfields for wastewater disposal. Nitrogen load reduction factors for soil bacteria activity are not applicable where seepage pits are used for wastewater disposal. Filtration of wastewater discharged into seepage pits located in soil or permeable bedrock will remove some bacteria load, but the nitrogen load carried in solution, is not removed by filtration.

Detail calculations for flow reduction and soil treatment reduction are summarized in Table 3.

3. Results

Using staff's loading factors for the numerical fate and transport model, staff estimates that wastewaters transport 30 lb/day of total nitrogen into Malibu Lagoon. This model also indicates that loads are increasing. Details of this numerical modeling approach are in the Mass Loading Estimate prepared by Dr. C.P. Lai that is appended to Technical Memorandum #4 as Attachment 4-1.

Also, using the same load factors applied to the 'spreadsheet' model, which characterized the wastewater transport into five hydrogeologic sectors, staff estimates that wastewaters transport 35 lb/day into Malibu Lagoon.

Staff's estimates of 30 lb/day to 35 lb/day fr om the numerical and 'spreadsheet' models are above two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

- Commercial Flows: The third-party models used significantly lower assumptions of commercial wastewater flows.
- Residential Concentrations: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are less than one-half of what staff assumed.
- Nitrogen concentration of commercial wastewater: The average nitrogen concentration of commercial wastewater discharges has decreased. Since 2004, eight additional OWTS have been installed at commercial properties in the Malibu Civic Center area.

The ranges in estimates of nitrogen loads to the Lagoon and key factors are shown in the following Table 5:

	Third-Party Estimates			**Staff Estimates**	
	Stone (2004) Model	**Questa (2005) Model**	**Tetra Tech (2002)**	**Staff Spreadsheet Model**	**Staff Numeric Model**
Commercial Flow Rate (gal/day)	62,166	100,000	75,000	127, 241	127, 241
Commercial Concentration (mg/L)	50.0	50.0	59.2	3-110	3-110
Commercial Load (lb/day)	26	42	35	42.1	42.1
Residential Flow Rate (gal/day)	126,121	126,121	54,800	139,300	139,300
Residential Concentration (mg/L)	20.0	20.0	59.2	45	45
Residential Load (lb/day)	21	21	27	52.3	52.3
Ratio of Mass loading	36%	32%	50%	37%	32%
Gross Load released from OWDSs	47	63	64	94.4	94.4
Net Load to Malibu Lagoon	17	20	32	34.9	30.2

Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the waste load allocation of 6 lb/day established in a TMDL[15] adopted by the US EPA on March 21, 2003.

4. Conclusion

Staff has determined that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 30 lb/day to 35 lb/day as well as third-party estimates that range from 17 lb/day to 32 lb/day. All estimates are well above targets needed to restore water quality and protect beneficial uses in Malibu Lagoon.

[15] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003), the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies load allocations for on-site wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

References:

American Water Works Association (AWWA). 1999. Residential End Users of Water. AWWA Research Foundation.

California Division of Mines and Geology, 2001, "Seismic Hazard Zone Report for the Malibu Beach 7.5- Minute Quadrangle, Los Angeles, California", Seismic Hazard Zone Report 050, dated 2001.

California Department of Water Resources, Bulletin 63-5, "Seawater Intrusion in California", October 1965.

Crites, R. and Tchobanoglous. G., "Small and Decentralized Wastewater Management Systems" McGraw-Hill, 1998.

Dibblee, T. W., 1982, "Geology of Santa Monica Mountains and Simi Hills, Southern California" , pages 94-130, in Geology and Mineral Wealth of the California Transverse Ranges", 1982.

Dibblee, T. W., "Geologic Map of the Malibu Beach Quadrangle, Los Angeles, California", published by Dibblee Geological Foundation, 1993.

Fife, D. and Minch, J., eds., "Geology and Mineral Wealth of the California Transverse Ranges", South Coast Geological Society, Inc., 1982.

Fugro West, Inc., 2005, "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development, Project No. 3354.001.06, dated March 7, 2005.

Geosyntec Consultants, Inc., 2007, "Geotechnical Site Exploration and Intrepretation of Subsurface Conditions, Malibu Legacy Park Site", Project No. LA0142-02, dated July 30, 2007.

Leighton and Associates, Inc. 1994, "Report of Geotechnical Studies for Planning Purposes in the Civic Center Area, City of Malibu, California", Project No. 2920647-01, dated July 30, 2007.

Malibu Water Company, personal communication between Grant Adamson and Toni Callaway. The Adamson Family owned the Malibu Water Company. Records on water supply wells located in the lower Malibu Creek watershed, are stored at Mariposa Land Company, LLC, offices on Cross Creek Road (2009).

Metcalf & Eddy, Inc., " Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

Metcalf & Eddy, Inc., "Wastewater Engineering. Treatment and Reuse" McGraw-Hill, 4th Edition, 2003.

Peter Warshall and Association (PWA). 1992. Malibu Wastewater Management Study.

Salvato, J. A., 1982, “Environmental Engineering and Sanitation”, John Wiley & Sons. 1982.

Stone Environmental, Inc., 2004, “Final Report, Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California”, Project No. 011269-W, dated August 30, 2004.

Stowell, R., personal communication, Notes from State Board Training Academy training course “Wastewater Engineering 2, Volume 1, The Advanced Class,”2009.

Tetra Tech, Inc., 2001, “Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies”, prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.

U.S. Environmental Protection Agency, 2003, “Total Maximum Daily Loads for Nutrients Malibu Creek Watershed”, 2003.

U.S. Environmental Protection Agency, 2002, “On-site Wasterwater Treatment Systems Manual”, 2002.

URS Greiner Woodward Clyde, 1999, “Study of Potential Water Quality Impacts on Malibu Creek and Lagoon From On-Site Septic Systems”. Project No. 964P170, dated June 7, 1999.

Van Beveren & Butelo, Inc., 2007, “Report of Geotechnical Investigation, Proposed Remodeling of Malibu Lumber Facility”, Project No. 07-020, dated July 26, 2007.

Van Beveren & Butelo, Inc., 2007, “Report of Hydrologic Study, Proposed Legacy Park Discharge Area”, Project No. 07-020.2, dated September 26, 2007.

Map 1 – Malibu Civic Center Area

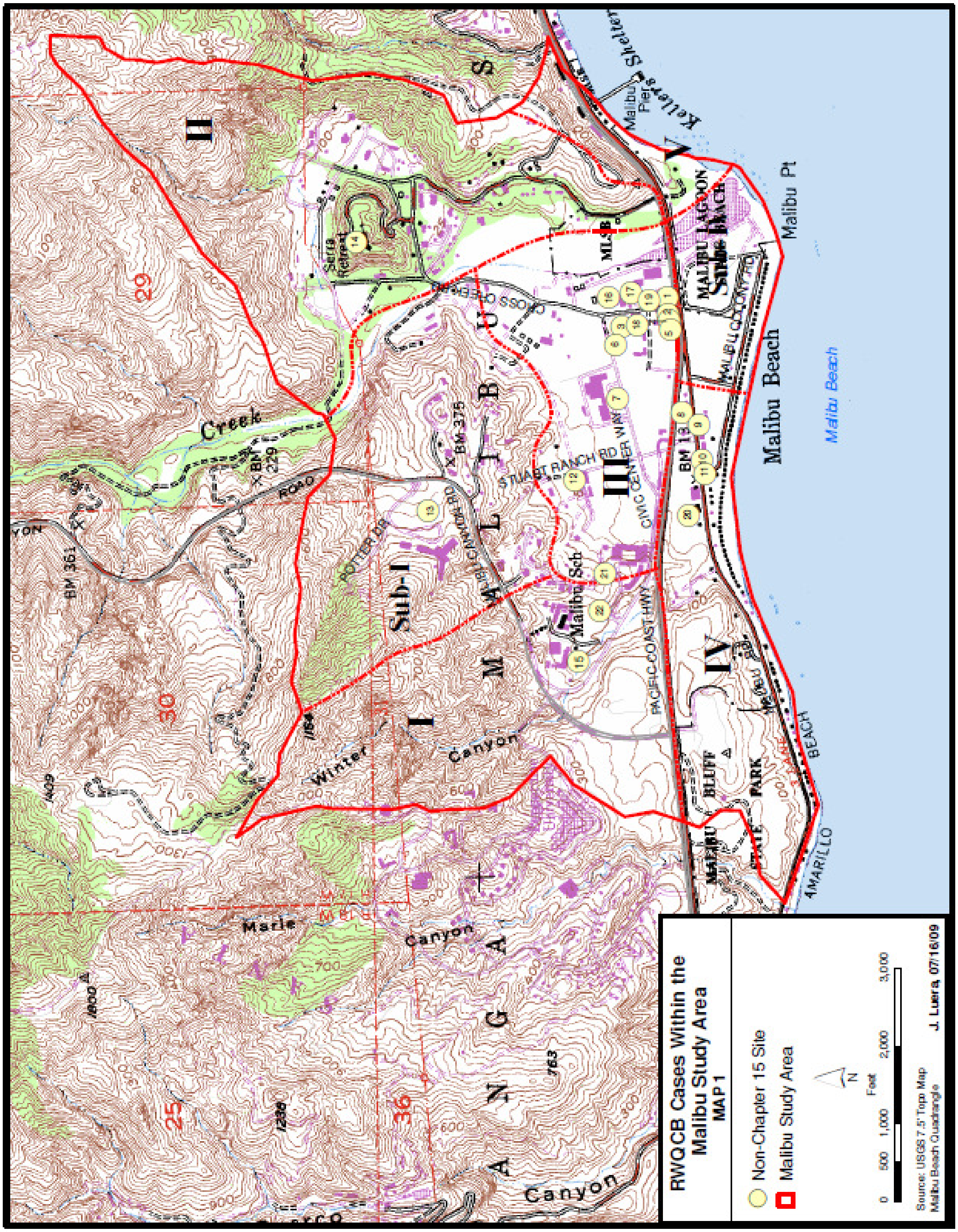


Figure – 1
Correlation of Groundwater and Tidal Levels

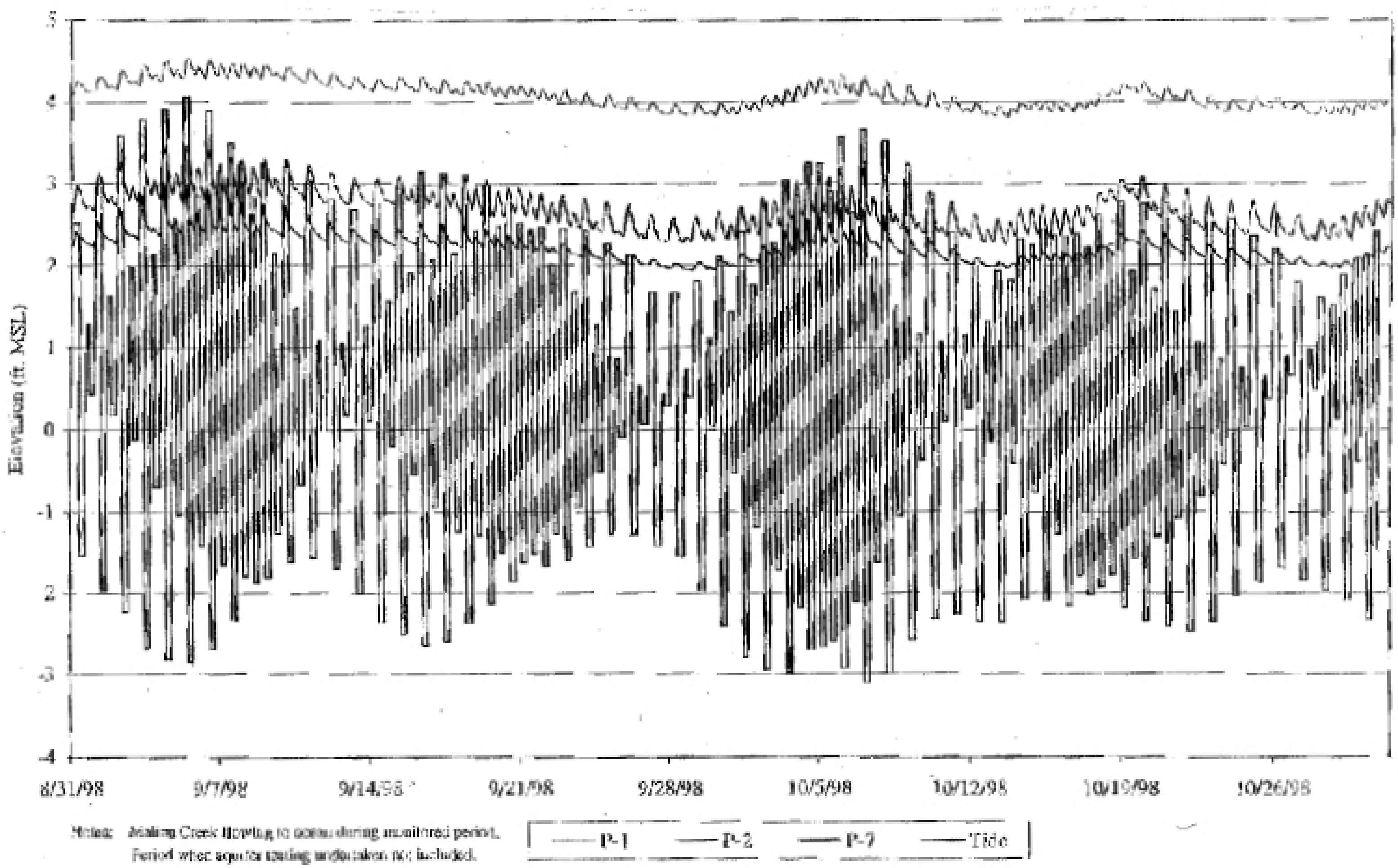


Figure -1 Adapted from Figure 4-1 in "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems", 1999, URS Greiner Woodward Clyde

Table 1 –Commercial and residential nitrogen loading (continue to next page)

Sector 1	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg-N/L)	TN Load (lbs/day)	TN Load (lbs/year)
HRL -3011 Malibu Cyn Rd	3,428	[B]3	45.0	1.29	469.9
L.A. Co. Main. Yard -3637 Winter Cyn Rd	252	[B]4	40.0	0.08	30.7
Malibu Colony Plaza -Disposal in Winter Cyn[D]	16,617	2	18.1	2.51	916.1
Malibu WPCP -3260 Vista Pacifica[D]	22,500	2	20.4	3.83	1,398.1
Webster Elementary -3602 Winter Cyn Rd	5,000	[B]3	75.0	3.13	1,142.2
Our Lady of Malibu -3625 Winter Cyn Rd	3,100	[B]3	75.0	1.94	708.2
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	[B]3	75.0	0.94	342.7
Commercial - 7 Business Facilities	52,397			13.72	5,007.8
Residential 61 homes	19,800	[B]1	45.0	7.44	2,713.9
Total				21.16	7,721.7

Sector 2	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg-N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Serra Retreat -3401 Serra Rd	428	[B]3	60.0	0.21	78.2
Commercial - 1 Business Facility	428			0.21	78.2
Residential 83 homes	30,900	[B]1	45.0	11.60	4,235.4
Total				11.82	4,313.6

Sector 3	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg-N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Malibu Animal Hospital -23431 PCH	1,260	[B]4	40.0	0.42	153.5
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	[B]7	40.0	1.35	492.0
Raquet Club -23847 Stuart Ranch Rd	1,500	[B]4	75.0	0.94	342.7
Prudential Realty -23405 PCH	450	[B]7	40.0	0.15	54.8
Malibu Country Mart I -3835 Cross Creek Rd	8,400	[B]4	80.0	5.61	2,046.9
Malibu Country Mart II 23410 Civic Ctr Wy	6,300	[B]4	80.0	4.21	1,535.1
Malibu Country Mart III -3900 Cross Creek Rd	3,400	[B]4	80.0	2.27	828.5
Malibu Shell -23387 PCH[D]	300	2	4.2	0.01	3.8
Malibu Prof. Arts Bldg -23440 Civic Ctr Wy	450	[B]7	40.0	0.15	54.8
Malibu Lumber -23479 PCH[D]	8,500	2	5.7	0.40	147.6
Mira Mar Properties -23805-23815 Stuart Ranch Rd	3,200	[B]7	40.0	1.07	389.9
J & P Limited -3806 Cross Creek Rd	500	[B]7	40.0	0.17	60.9
So. Calif. Edison	400	[B]7	40.0	0.13	48.7
Verizon South, Inc. -3705 Cross Creek Rd	400	[B]7	40.0	0.13	48.7
Mariposa Land Company, LLC -3728 Cross Creek Rd	1,500	[B]7	40.0	0.50	182.8
Malibu Creek Plaza/Malibu Village[D]	11,000	2	3.0	0.28	100.5
Commercial - 16 Business Facilities	51,598			17.78	6,491.3
Residential 2 homes	800	[B]1	45.0	0.30	109.7
Total				18.08	6,600.9

Sector 4	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg-N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Malibu Rd., LLC -23676-23712 Malibu Rd	1,000	[B]7	40.0	0.33	121.8
Morton-Gerson -23730 Malibu Rd	150	[B]7	40.0	0.05	18.3
L.A. Co. Fire Station #88 -23720 Malibu Rd	540	6	30.0	0.14	49.3
Lisa Krasnoff -23655 Malibu Colony Rd	400	[B]7	40.0	0.13	48.7
Mesa, LLC 23915 PCH	400	[B]7	40.0	0.13	48.7
Commercial - 5 Business Facilities	2,490			0.79	286.9
Residential 223 homes	78,200	[B]1	45.0	29.37	10,718.6
Total				30.15	11,005.5

Sector 5	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg-N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Surfrider Co. Beach -23060 PCH	3,188	[B]4	40.0	1.06	388.4
Malibu Pier State Park -23000 PCH[D]	3,000	2	11.7	0.29	106.9
Malibu Shores Motel -23033 PCH	1,797	[B]4	60.0	0.90	328.4
Malibu Beach Inn -22878 PCH[D]	2,843	2	31.9	0.76	276.2
Jack-in-the-Box -23017 PCH[D]	1,800	6	26.3	0.39	144.0
Malibu Plaza 22917 PCH[B]	1,500	[B]7	40.0	0.50	182.8
Malibu Inn & Restaurant 22969 PCH[C]	6,200	6	110.0	5.69	2,077.3
Surfshack/Fish Grill -22935 PCH	400	[B]4	80.0	0.27	97.5
Spic & Span Cleaners/Chabad -22941 PCH[B]	1,000	[B]4	40.0	0.33	121.8
Commercial - 9 Business Facilities	20,328			9.60	3,504.0
Residential 23 homes	9,600	[B]1	45.0	3.61	1,315.8
Total				13.21	4,819.9

Malibu Civic Center Area	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg-N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Commercial	127,241			42.10	15,368.3
Residential	139,300			52.31	19,093.4
Total	**266,541**			**94.42**	**34,461.6**

Note:

[A] Measured or discharger reported flow underlined

[B] Estimated flow and TN concentration

[C] Discharger reported TN concentration

[D] Advanced OWDS treatment

Category

1-Residential discharge after "in-tank treatment" reduction
2-Multi-Use commercial with advanced wastewater treatment
3-Facilities such as schools with food service and high restroom usage
4-Multi-Use commercial with septic system
5-Stand alone restaurant with septic system
6- Assigned TN concentration from another site with the same advanced treatment system
7- Office building with low domestic strength wastewater

Table 2 –List of Residential Septic Systems

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458027034	3547 Malibu Colony Rd	Multi Family	6	3	On-site
I	4458026007	3400 Coast View Dr	Residential	4		On-site
I	4458027002	3401 Coast View Dr	Residential	4	4	On-site
I	4458026006	3436 Coast View Dr	Residential	2	2	On-site
I	4558026015	3502 Coast View Dr	Residential	4	3	On-site
I	4458026014	3504 Coast View Dr	Residential	3	4	On-site
I	4458026004	3524 Coast View Dr	Residential	3	3	On-site
I	4458026003	3536 Coast View Dr	Residential	2	2	On-site
I	4458027030	Coast View Dr	Residential			On-site
I	4458025020	3207 Colony View Cir	Residential	3	3	On-site
I	4458025016	3213 Colony View Cir	Residential	4	4	On-site
I	4458025015	3215 Colony View Cir	Residential	3	4	On-site
I	4458025012	3216 Colony View Cir	Residential	3	4	On-site
I	4458025010	3217 Colony View Cir	Residential	3	2	On-site
I	4458025011	3220 Colony View Cir	Residential	3	3	On-site
I	4458025025	3211 Colony View Cir	Residential	5	5	On-site
I	4458024004	32701 Harbor Vista Dr	Residential	3	3	On-site
I	4458024043	23702 Harbor Vista Dr	Residential	3	2	On-site
I	4458024025	23704 Harbor Vista Dr	Residential	4	3	On-site
I	4458024031	23706 Harbor Vista Dr	Residential	3	2	On-site
I	4458024001	23708 Harbor Vista Dr	Residential	3	2	On-site
I	4458024029	23721 Harbor Vista Dr	Residential	3	3	On-site
I	4458025014	23722 Harbor Vista Dr	Residential	3	4	On-site
I	4458024034	23741 Harbor Vista Dr	Residential	3	2	On-site
I	4458025013	23748 Harbor Vista Dr	Residential	3	3	On-site
I	4458024009	23803 Harbor Vista Dr	Residential	6	7	On-site
I	4458025019	23812 Harbor Vista Dr	Residential	3	2	On-site
I	4458024010	23813 Harbor Vista Dr	Residential	3	2	On-site
I	4458024011	23831 Harbor Vista Dr	Residential	5	4	On-site
I	4458024012	23837 Harbor Vista Dr	Residential	3	1	On-site
I	4458025024	23838 Harbor Vista Dr	Residential	5	6	On-site
I	4458025006	23850 Harbor Vista Dr	Residential	3	3	On-site
I	4458025018	23858 Harbor Vista Dr	Residential	3	3	On-site
I	4458024013	23843 Harbor Vista Dr	Residential	3	2	On-site
I	4458025017	3224 Malibu Canyon Rd	Residential	2	2	On-site
I	4458025004	3338 Malibu Canyon Rd	Residential			On-site
I	4458024038	23800 Malibu Crest Dr	Residential	4	3	On-site
I	4458024042	23805 Malibu Crest Dr	Residential	4	4	On-site
I	4458024041	23806 Malibu Crest Dr	Residential	5	6	On-site
I	4458024039	23808 Malibu Crest Dr	Residential	3	2	On-site
I	4458024040	23812 Malibu Crest Dr	Residential	3	4	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458024022	23814 Malibu Crest Dr	Residential	4	5	On-site
I	4458024023	23816 Malibu Crest Dr	Residential	3	2	On-site
I	4458024021	23854 Malibu Crest Dr	Residential	2	3	On-site
I	4458024015	23870 Malibu Crest Dr	Residential	3	4	On-site
I	4458024014	23880 Malibu Crest Dr	Residential	4	4	On-site
I	4458026010	23901 Malibu Knolls Rd	Residential	4	1	On-site
I	4458026011	23903 Malibu Knolls Rd	Residential	4	3	On-site
I	4458026012	23905 Malibu Knolls Rd	Residential	3	2	On-site
I	4458026013	23907 Malibu Knolls Rd	Residential	3	3	On-site
I	4458026009	23908 Malibu Knolls Rd	Residential	3	3	On-site
I	4458025001	23915 Malibu Knolls Rd	Residential	3	2	On-site
I	4458026008	23916 Malibu Knolls Rd	Residential	4	4	On-site
I	4458025022	23933 Malibu Knolls Rd	Residential	2	2	On-site
I	4458027904	Winter Canyon Rd	Multi-Family			
I	4458027025	3625 Winter Canyon Rd	Residential	6	6	On-site
I	4458027003	3431 Coast View Dr	Residential	3	2	On-site
I	4458027004	3453 Coast View Dr	Residential	5	5	On-site
I	4458027005	3505 Coast View Dr	Multi-Family	4	3	On-site
I	4458027029	3525 Coast View Dr	Residential	3	3	On-site
subtotal			61	198	178	
II	4452015035	3501 Cross Creek LN	Residential	4	4	On-site
II	4452015034	3509 Cross Creek LN	Residential	3	4	On-site
II	4452015023	3510 Cross Creek LN	Residential	4	4	On-site
II	4452015033	3511 Cross Creek LN	Residential	5	6	On-site
II	4452015025	3512 Cross Creek LN	Residential	3	4	On-site
II	4452015026	3520 Cross Creek LN	Residential			On-site
II	4452015031	3535 Cross Creek LN	Residential	4	4	On-site
II	4452015027	3538 Cross Creek LN	Residential	4	3	On-site
II	4452015030	3539 Cross Creek LN	Residential	4	4	On-site
II	4452015042	3550 Cross Creek LN	Residential	5	4	On-site
II	4452014006	3415 Cross Creek Rd	Residential	3	3	On-site
II	4452015024	Cross Creek LN	Residential	5	5	On-site
II	4458023003	3469 Cross Creek Rd	Residential	4	9	On-site
II	4458023009	3515 Cross Creek Rd	Residential	4	4	On-site
II	4452015029	3551 Cross Creek LN	Residential			On-site
II	4458022021	3565 Cross Creek Rd	Residential	4	3	On-site
II	4458022004	Cross Creek Rd	Residential			On-site
II	4458022003	3661 Cross Creek Rd	Residential	2	2	On-site
II	4452015003	23110 Mariposa De Oro St	Residential	5	5	On-site
II	4452015014	2311 Mariposa De Oro St	Residential	3	3	On-site
II	4452015007	23122 Mariposa De Oro St	Residential	4	4	On-site
II	4452015010	23140 Mariposa De Oro St	Residential	5	4	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452015040	23146 Mariposa De Oro St	Residential	6	5	On-site
II	4452015006	23155 Mariposa De Oro St	Residential	4	5	On-site
II	4452015036	23160 Mariposa De Oro St	Residential	2	1	On-site
II	4452015021	23210 Mariposa De Oro St	Residential	5	5	On-site
II	4452015020	23215 Mariposa De Oro St	Residential	3	2	On-site
II	4452015022	23222 Mariposa De Oro St	Residential	5	5	On-site
II	4452015019	23233 Mariposa De Oro St	Residential	3	3	On-site
II	4452015018	23255 Mariposa De Oro St	Residential	5	5	On-site
II	4452027018	23247 Palm Canyon Ln	Residential	5	6	On-site
II	4452027016	23267 Palm Canyon Ln	Residential	2	2	On-site
II	4452027013	23301 Palm Canyon Ln	Residential	4	7	On-site
II	4452027012	23333 Palm Canyon Ln	Residential	3	4	On-site
II	4452027011	23333 Palm Canyon Ln	Residential	6	5	On-site
II	4452014004	23344 Palm Canyon Ln	Residential	4	3	On-site
II	4452012028	23500 Palm Canyon Ln	Residential	5	5	On-site
II	4452027021	3200 Retreat Ct	Residential	8	8	On-site
II	4452027022	3201 Retreat Ct	Residential	6	7	On-site
II	4452027019	3210 Retreat Ct	Residential	5	6	On-site
II	4452027023	3211 Retreat Ct	Residential	5	6	On-site
II	4452026008	3216 Serra Rd	Residential	5	5	On-site
II	4452026009	3220 Serra Rd	Residential	4	3	On-site
II	4452026007	3226 Serra Rd	Residential	5	5	On-site
II	4452026006	3226 Serra Rd	Residential			On-site
II	4452026010	3250 Serra Rd	Residential	4	6	On-site
II	4452026011	3264 Serra Rd	Residential	5	5	On-site
II	4452026019	3268 Serra Rd	Residential	4	4	On-site
II	4452026018	3270 Serra Rd	Residential			On-site
II	4452026012	3314 Serra Rd	Residential	4	3	On-site
II	4452026013	3350 Serra Rd	Residential	5	4	On-site
II	4452026016	3410 Serra Rd	Residential	5	4	On-site
II	4452026014	3426 Serra Rd	Residential	4	3	On-site
II	4452026015	3434 Serra Rd	Residential	4	4	On-site
II	4452018006	3611 Serra Rd	Residential	4	3	On-site
II	4452026003	Serra Rd	Residential			On-site
II	4452018011	3549 Serra Rd	Residential	3	3	On-site
II	4452013001	3556 Serra Rd	Residential	4	3	On-site
II	4452018012	3557 Serra Rd	Residential	3	3	On-site
II	4452013002	3560 Serra Rd	Residential	3	2	On-site
II	4452018013	3567 Serra Rd	Residential	4	4	On-site
II	4452013003	3574 Serra Rd	Residential	6	7	On-site
II	4452018015	3609 Serra Rd	Residential	2	3	On-site
II	4452013009	3610 Serra Rd	Residential	4	4	On-site
II	4452018008	3615 Serra Rd	Residential			On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452018016	3621 Serra Rd	Residential	4	4	On-site
II	4452018009	3623 Serra Rd	Residential	4	2	On-site
II	4452018017	3625 Serra Rd	Residential	4	2	On-site
II	4452018018	3627 Serra Rd	Residential	5	4	On-site
II	4452018019	3629 Serra Rd	Residential	4	3	On-site
II	4452018020	3631 Serra Rd	Residential	5	4	On-site
II	4452012014	3633 Serra Rd	Residential	4	4	On-site
II	4452012012	3635 Serra Rd	Residential	3	3	On-site
II	4452012015	3637 Serra Rd	Residential	1	1	On-site
II	4452013005	3644 Serra Rd	Residential	4	7	On-site
II	4452017001	3700 Serra Rd	Residential	4	3	On-site
II	4452012007	3701 Serra Rd	Residential	3	3	On-site
II	4452012016	3705 Serra Rd	Residential	4	3	On-site
II	4452012013	3707 Serra Rd	Residential	2	3	On-site
II	4452012022	3227 Serra Rd	Residential	4	4	On-site
II	4452012009	3737 Serra Rd	Residential	4	4	On-site
II	4452012011	3751 Serra Rd	Residential	3	4	On-site
II	4452012020	3811 Serra Rd	Residential	4	6	On-site
subtotal			83	309	311	
III	4452027010	3200 Cross Creek RD	Residential	3	3	On-site
III	4452027009	3232 Cross Creek RD	Residential	5	5	On-site
subtotal			2	8	8	
IV	4458004044	70 Malibu Colony Rd	Residential	4	3	On-site
IV	4452008025	112 Malibu Colony Rd	Residential	5	5	On-site
IV	4452008017	23314 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008016	23316 Malibu Colony Rd	Residential	4	4	On-site
IV	4452008014	23318 Malibu Colony Rd	Residential	3	5	On-site
IV	4452008030	23324 Malibu Colony Rd	Residential	5	7	On-site
IV	4452010017	23325 Malibu Colony Rd	Residential	2	2	On-site
IV	4452008028	23330 Malibu Colony Rd	Residential	2	4	On-site
IV	4452010024	23331 Malibu Colony Rd	Residential	2	3	On-site
IV	4452008027	23334 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010023	23337 Malibu Colony Rd	Residential			On-site
IV	4452008026	23338 Malibu Colony Rd	Residential	3	4	On-site
IV	4452008024	23346 Malibu Colony Rd	Residential	3	2	On-site
IV	4452010032	23349 Malibu Colony Rd	Residential	4	4	On-site
IV	4452008023	23350 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010031	23351 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008022	23354 Malibu Colony Rd	Residential	2	3	On-site
IV	4452008021	23356 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008020	23360 Malibu Colony Rd	Residential	3	4	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4452010012	23401 Malibu Colony Rd	Residential	4	6	On-site
IV	4452008019	23402 Malibu Colony Rd	Residential	6	4	On-site
IV	4452009027	23410 Malibu Colony Rd	Residential	3	3	On-site
IV	4452009017	23416 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009016	23418 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010008	23425 Malibu Colony Rd	Residential	3	4	On-site
IV	4452009024	23426 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010028	23431 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010009	23435 Malibu Colony Rd	Residential			On-site
IV	4452009018	23438 Malibu Colony Rd	Residential	4	6	On-site
IV	4452009019	23440 Malibu Colony Rd	Residential	5	6	On-site
IV	4452010029	23441 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009022	23444 Malibu Colony Rd	Residential	4	3	On-site
IV	4452010027	23445 Malibu Colony Rd	Residential	5	3	On-site
IV	4452009021	23446 Malibu Colony Rd	Residential	5	4	On-site
IV	4452010005	23449 Malibu colony Rd	Residential	3	5	On-site
IV	4452009020	23450 Malibu Colony Rd	Residential	4	6	On-site
IV	4452009015	23456 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010003	23457 Malibu Colony Rd	Residential	3	4	On-site
IV	4458004031	23460 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004032	23500 Malibu Colony Rd	Residential	3	5	On-site
IV	4452010002	23501 Malibu Colony Rd	Residential	2	1	On-site
IV	4452010019	23505 Malibu Colony Rd	Residential	4	4	On-site
IV	4458004033	23506 Malibu Colony Rd	Residential	2	4	On-site
IV	4458004034	23510 Malibu Colony Rd	Residential	3	3	On-site
IV	4458003023	23511 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004035	23512 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003022	23515 Malibu Colony Rd	Residential	5	5	On-site
IV	4458004036	23516 Malibu Colony Rd	Residential	3	2	On-site
IV	4458003021	23517 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004037	23520 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004038	23524 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004039	23526 Malibu Colony Rd	Residential	5	7	On-site
IV	4458004040	23530 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003019	23531 Malibu Colonr Rd	Residential	4	5	On-site
IV	4458003018	23533 Malibu colony rd	Residential	4	3	On-site
IV	4458004041	23536 Malibu colony rd	Residential	4	3	On-site
IV	4458004042	23538 Malibu Colony Rd	Residential	5	4	On-site
IV	4458003017	23543 Malibu Colony Rd	Residential	5	3	On-site
IV	4458004043	23544 Malibu Colony Rd	Residential	5	4	On-site
IV	4458003015	23555 Malibu Colony Rd	Residential	1	1	On-site
IV	4458004046	23556 Malibu Colony Rd	Residential	2	2	On-site
IV	4458004047	23560 Malibu Colony Rd	Residential	4	4	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458003014	23561 Malibu Colony Rd	Residential	5	4	On-site
IV	4458004048	23562 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004049	23566 Malibu Colony Rd	Residential	3	1	On-site
IV	4458003013	23567 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004050	23570 Malibu Colony Rd	Residential	5	3	On-site
IV	4458004051	23600 Malibu Colony Rd	Residential	2	3	On-site
IV	4458003012	23601 Malibu Colony Rd	Residential			On-site
IV	4458004052	23604 Malibu Colony Rd	Residential	2	3	On-site
IV	4458004053	23608 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004054	23610 Malibu Colony Rd	Residential	5	6	On-site
IV	4458003027	23611 Malibu Colony Rd	Residential	4	6	On-site
IV	4458004055	23614 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003026	23615 Malibu Colony Rd	Residential	4	5	On-site
IV	4458005040	23618 Malibu Colony Rd	Residential	4	5	On-site
IV	4458005039	23620 Malibu Colony Rd	Residential	3	7	On-site
IV	4458005038	23622 Malibu Colony Rd	Residential	7	4	On-site
IV	4458003009	23623 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005037	23626 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003008	23629 Malibu Colony Rd	Residential			On-site
IV	4458005036	23630 Malibu Colony Rd	Residential	4	3	On-site
IV	4458005035	23632 Malibu Colony Rd	Residential	5	3	On-site
IV	4458005034	23634 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003030	23639 Malibu Colony Rd	Residential	2	2	On-site
IV	4458005033	23640 Malibu Colony Rd	Residential	3	4	On-site
IV	4458003004	23641 Malibu Colony Rd	Residential			On-site
IV	4458005032	23644 Malibu Colony Rd	Residential	5	6	On-site
IV	4458005031	23648 Malibu Colony Rd	Residential	3	4	On-site
IV	4458003029	23649 Malibu Colony Rd	Residential	4	4	On-site
IV	4458005030	23652 Malibu Colony Rd	Residential	3	2	On-site
IV	4458005029	23654 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003028	23655 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005028	23660 Malibu Colony Rd	Residential	4	5	On-site
IV	4458002014	23661 Malibu Colony Rd	Residential	5	5	On-site
IV	4458005027	23664 Malibu Colony Rd	Residential	3	2	On-site
IV	4458002011	23667 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005026	23668 Malibu Colony Rd	Residential	3	2	On-site
IV	4458005025	23672 Malibu Colony Rd	Residential	4	5	On-site
IV	4458002010	23673 Malibu Colony Rd	Residential	4	2	On-site
IV	4458005024	23674 Malibu Colony Rd	Residential	3	4	On-site
IV	4458005023	23678 Malibu Colony Rd	Residential	6	6	On-site
IV	4458005022	23684 Malibu Colony Rd	Residential	4	3	On-site
IV	4458002006	23687 Malibu Colony Rd	Residential	5	4	On-site
IV	4458005021	23700 Malibu Colony Rd	Residential	8	8	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458006041	23704 Malibu Colony Rd	Residential	6	3	On-site
IV	4458002004	23705 Malibu Colony Rd	Residential	4	5	On-site
IV	4458006040	23708 Malibu Colony Rd	Residential	5	5	On-site
IV	4458002003	23709 Malibu Colony Rd	Residential	4	3	On-site
IV	4458006038	23712 Malibu Colony Rd	Residential	6	7	On-site
IV	4458002017	23713 Malibu Colony Rd	Residential	2	1	On-site
IV	4458006037	23716 Malibu Colony Rd	Residential	5	4	On-site
IV	4458006036	23720 Malibu Colony Rd	Residential	2	3	On-site
IV	4458006035	23730 Malibu Colony Rd	Residential	5	5	On-site
IV	4458006034	23736 Malibu Colony Rd	Residential	4	4	On-site
IV	4452005025	23006 Malibu Rd	Residential	3	3	On-site
IV	4458004045	23554 Malibu Rd	Residential	3	2	
IV	4458006033	23740 Malibu Rd	Residential	5	4	On-site
IV	4458006032	23746 Malibu Rd	Residential	4	3	On-site
IV	4458006031	23750 Malibu Rd	Residential	4	5	On-site
IV	4458006030	23752 Malibu Rd	Residential	4	4	On-site
IV	4458006029	23754 Malibu Rd	Residential	4	4	On-site
IV	4458006028	23758 Malibu Rd	Residential	3	4	On-site
IV	4458006027	237562 Malibu Rd	Residential	3	4	On-site
IV	4458006026	23764 Malibu Rd	Residential	3	5	On-site
IV	4458006025	23768 Malibu Rd	Residential	3	4	On-site
IV	4458006023	23800 Malibu Rd	Residential	9	10	On-site
IV	4458006022	23808 Malibu Rd	Residential	4	4	On-site
IV	4458007028	23812 Malibu Rd	Residential	4	1	On-site
IV	4458007027	23816 Malibu Rd	Residential	2	3	On-site
IV	4458007026	23822 Malibu Rd	Residential	4	7	On-site
IV	4458007025	23826 Malibu Rd	Residential	4	3	On-site
IV	4458007024	23832 Malibu Rd	Residential	5	3	On-site
IV	4458007023	23834 Malibu Rd	Residential	2	3	On-site
IV	4458007022	23844 Malibu Rd	Residential	3	2	On-site
IV	4458007021	23850 Malibu Rd	Residential	7	5	On-site
IV	4458007016	23858 Malibu Rd	Residential	5	6	On-site
IV	4458007015	23864 Malibu Rd	Residential			On-site
iV	4458007020	23868 Malibu Rd	Residential	5	6	On-site
IV	4458007019	23872 Malibu Rd	Residential	3	2	On-site
IV	4458007018	23900 Malibu Rd	Residential	3	2	On-site
IV	4458007017	23910 Malibu Rd	Residential	3	6	On-site
IV	4458008017	23917 Malibu Rd	Residential	5	4	On-site
IV	4458008016	23920 Malibu Rd	Residential	5	7	On-site
IV	4458008015	23926 Malibu Rd	Residential	6	5	On-site
IV	4458008014	23930 Malibu Rd	Residential	4	5	On-site
IV	4458008013	23936 Malibu Rd	Residential	4	4	On-site
IV	4458008018	23940 Malibu Rd	Residential	6	7	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458008003	23950 Malibu Rd	Residential	4	5	On-site
IV	4458008002	23952 Malibu Rd	Residential	2	3	On-site
IV	4458008001	23956 Malibu Rd	Residential	5	3	On-site
IV	4458009013	23962 Malibu Rd	Residential	3	2	On-site
IV	4458009012	24000 Malibu Rd	Residential	4	3	On-site
IV	4458009009	24016 Malibu Rd	Residential	3	3	On-site
IV	4458009001	24056 Malibu Rd	Residential	2	1	On-site
IV	4458010015	24058 Malibu Rd	Residential	4	2	On-site
IV	4458010016	24102 Malibu Rd	Residential	4	4	On-site
IV	4458010017	24108 Malibu Rd	Residential	3	4	On-site
IV	4458010019	24116 Malibu Rd	Residential	3	3	On-site
IV	4458010018	24116 Malibu Rd	Residential	3	3	On-site
IV	4458010012	24120 Malibu Rd	Residential	3	3	On-site
IV	4458010011	24124 Malibu Rd	Residential	2	2	On-site
IV	4458010010	24128 Malibu Rd	Residential	3	4	On-site
IV	4458010008	24134 Malibu Rd	Residential	2	3	On-site
IV	4458010007	24138 Malibu Rd	Residential	3	3	On-site
IV	4458010006	24142 Malibu Rd	Residential	2	2	On-site
IV	4458010005	24146 Malibu Rd	Residential	4	4	On-site
IV	4458010004	24150 Malibu Rd	Residential	4	3	On-site
IV	4458010003	24154 Malibu Rd	Residential	2	2	On-site
IV	4458010001	24172 Malibu Rd	Residential	3	2	On-site
IV	4458011002	24212 Malibu Rd	Residential	2	2	On-site
IV	4458011003	24216 Malibu Rd	Residential	3	2	On-site
IV	4458018005	24001 Malibu Rd	Residential	3	3	On-site
IV	4458018020	24031 Malibu Rd	Residential	3	2	On-site
IV	4458018011	24109 Malibu Rd	Residential	3	2	On-site
IV	4458018012	24111 Malibu Rd	Residential	3	2	On-site
IV	4458010019	24112 Malibu Rd	Residential	4	4	On-site
IV	4458011004	24222 Malibu Rd	Residential	2	2	On-site
IV	4458011005	24228 Malibu Rd	Residential	2	2	On-site
IV	4458011007	24236 Malibu Rd	Residential	3	3	On-site
IV	4458011008	24246 Malibu Rd	Residential	2	2	On-site
IV	4458011009	24254 Malibu Rd	Residential	3	4	On-site
IV	4458011010	24266 Malibu Rd	Residential	2	2	On-site
IV	4458011012	24314 Malibu Rd	Residential	3	3	On-site
IV	4458011013	24320 Malibu Rd	Residential	1	4	On-site
IV	4458011032	24330 Malibu Rd	Residential	4	4	On-site
IV	4458011018	24348 Malibu Rd	Residential	2	1	On-site
IV	4458011019	24352 Malibu Rd	Residential	3	2	On-site
IV	4458011021	24380 Malibu Rd	Residential	4	5	On-site
IV	4458011022	24402 Malibu Rd	Residential	2	3	On-site
IV	4458011023	24408 Malibu Rd	Residential	3	3	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458011024	24414 Malibu Rd	Residential	3	3	On-site
IV	4458011027	24434 Malibu Rd	Residential	7	6	On-site
IV	4458011028	24436 Malibu Rd	Residential	5	4	On-site
IV	4458011029	24444 Malibu Rd	Residential	3	3	On-site
IV	4458011030	24450 Malibu Rd	Residential	3	3	On-site
IV	4458011031	24456 Malibu Rd	Residential	2	3	On-site
IV	4458012001	24460 Malibu Rd	Residential	3	5	On-site
IV	4458012002	24466 Malibu Rd	Residential	5	4	On-site
IV	4458012003	24470 Malibu Rd	Residential	3	3	On-site
IV	4458012004	24476 Malibu Rd	Residential	3	3	On-site
IV	4458012005	24508 Malibu Rd	Residential	6	5	On-site
IV	4458012006	24514 Malibu Rd	Residential	2	2	On-site
IV	4458012007	24518 Malibu Rd	Residential	3	2	On-site
IV	4458012008	24524 Malibu Rd	Residential	2	2	On-site
IV	4458012009	24528 Malibu Rd	Residential	3	2	On-site
IV	4458012010	24534 Malibu Rd	Residential	2	1	On-site
IV	4458012011	24538 Malibu Rd	Residential	2	1	On-site
IV	4458012012	24542 Malibu Rd	Residential	3	3	On-site
IV	4458012013	24548 Malibu Rd	Residential	3	3	On-site
IV	4458012014	24554 Malibu Rd	Residential	3	2	On-site
IV	4458012035	24560 Malibu Rd	Residential	3	4	On-site
IV	4458012036	24572 Malibu Rd	Residential	3	4	On-site
IV	4458012017	24604 Malibu Rd	Residential	3	4	On-site
IV	4458012018	24608 Malibu Rd	Residential	3	4	On-site
IV	4458012019	24612 Malibu Rd	Residential	3	4	On-site
IV	4458012020	24616 Malibu Rd	Residential	4	5	On-site
IV	4458012021	24620 Malibu Rd	Residential	3	3	On-site
IV	4458012021	24626 Malibu Rd	Residential	3	3	On-site
IV	4452008018	23406 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009026	23414 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009025	23422 Malibu Colony Rd	Residential	4	4	On-site
IV	4452009023	23430 Malibu Colony Rd	Residential	6	6	On-site
subtotal			223	782	793	On-site
V	4452025006	3395 Sweetwater Mesa Rd	Residential	2	2	On-site
V	4452016004	3401 Sweetwater Mesa Rd	Residential	5	10	On-site
V	4452016019	3415 Sweetwater Mesa Rd	Residential	6	7	On-site
V	4452016020	3431 Sweetwater Mesa Rd	Residential	5	7	On-site
V	4452016007	3451 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452017004	3509 Sweetwater Mesa Rd	Residential	5	8	On-site
V	4452017005	3535 Sweetwater Mesa Rd	Residential	6	7	On-site
V	4452017009	3620 Sweetwater Mesa Rd	Residential	6	8	On-site
V	4452013008	3655 Sweetwater Mesa Rd	Residential	4	4	On-site

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
V	4452013007	3669 Sweetwater Mesa Rd	Residential	2	2	On-site
V	4452016008	3330 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016018	3362 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016017	3380 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016016	3416 Sweetwater Mesa Rd	Residential	3	3	On-site
V	4452016015	3464 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452017008	3556 Sweetwater Mesa Rd	Residential	6	6	On-site
V	4452005004	23018 Pacific Coast Hwy	Residential	3	3	On-site
V	4452005022	23022 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005018	23030 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005002	23034 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005001	23038 Pacific Coast Hwy	Residential	3	2	On-site
V	4452019008	22931 Pacific Coast Hwy	Residential	2	3	On-site
V	4452005020	22860 Pacific Coast Hwy	Multi Family	12	13	On-site
subtotal			23	96	108	
TOTAL			392	1,393	1,398	

Table 3 - Total Nitrogen Load to the Lagoon After Adjustment of Flow and Leach Field Reduction

Table 3 Total Nitrogen Loading to the Lagoon After Adjustment of Flow and Leach Field Reduction

Sector 1	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
HRL -3011 Malibu Cyn Rd*	3,428	45%	1,543	45.0	>10	soil & bedrock	0%	45.0	0.58
L.A. Co. Main. Yard -3637 Winter Cyn Rd	252	1%	3	40.0	10	sand, silt & clay	20%	32.0	0.00
Malibu Colony Plaza -Disposal in Winter Cyn*	16,617	1%	166	18.1	varies	sand & silt	0%	18.1	0.03
Malibu WPCP -3260 Vista Pacifica*	22,500	1%	225	20.4	varies	sand & silt	0%	20.4	0.04
Webster Elementary^ -3602 Winter Cyn Rd	5,000	1%	50	75.0	15	sand & silt	20%	60.0	0.03
Our Lady of Malibu^ -3625 Winter Cyn Rd	3,100	1%	31	75.0		sand & silt	0%	75.0	0.02
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	45%	675	75.0		sand & silt	0%	75.0	0.42
Commercial - 7 Business Facilities	52,397		2,692						1.11
Residential 61 homes	19,800	45%	8,910	45.0				45.0	3.35
Total									4.46

*Seepage Pit Disposal or Failed Leachfield = 0% soil treatment

Sector 2	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Serra Retreat -3401 Serra Rd	428	95%	407	60.0	>10	sand & silt	20%	48.0	0.16
Commercial - 1 Business Facility	428		407						0.16
Residential 83 homes	30,900	95%	29,355	45.0				45.0	11.02
Total									11.19

Sector 3	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Malibu Animal Hospital -23431 PCH	1,260	95%	1,197	40.0	10	sand, silt & clay	20%	32.0	0.32
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	60%	2,423	40.0	>10	sand, silt & clay	20%	32.0	0.65
Raquet Club -23847 Stuart Ranch Rd	1,500	20%	300	75.0	ukn.	sand, silt & clay	0%	75.0	0.19
Prudential Realty -23405 PCH	450	95%	428	40.0	10	mostly sand	20%	32.0	0.11
Malibu Country Mart I -3835 Cross Creek Rd*	8,400	95%	7,980	80.0	<5	sand & silt	0%	80.0	5.33
Malibu Country Mart II 23410 Civic Ctr Wy*	6,300	95%	5,985	80.0	<5	sand & silt	0%	80.0	4.00
Malibu Country Mart III -3900 Cross Creek Rd*	3,400	95%	3,230	80.0	<5	mostly sand & silt	0%	80.0	2.16
Malibu Shell^^ -23387 PCH	300	95%	285	4.2	5 to 10	mostly sand	20%	3.4	0.01
Malibu Prof. Arts Bldg -23440 Civic Ctr Wy	450	60%	270	40.0	10	sand, silt & clay	10%	36.0	0.08
Malibu Lumber -23479 PCH	8,500	60%	5,100	5.7	5 to 10	fill, sand, silt & clay	20%	4.6	0.19
Mira Mar Properties -23805-23815 Stuart Ranch Rd*	3,200	20%	640	40.0	>10	sand, silt & clay	0%	40.0	0.21
J & P Limited -3806 Cross Creek Rd	500	95%	475	40.0	10	mostly sand	20%	32.0	0.13
So. Calif. Edison	400	95%	380	40.0		mostly sand	20%	32.0	0.10
Verizon South, Inc. -3705 Cross Creek Rd	400	95%	380	40.0		sand & silt	20%	32.0	0.10
Mariposa Land Company, LLC -3728 Cross Creek Rd	1,500	95%	1,425	40.0		mostly sand	20%	32.0	0.38
Malibu Creek Plaza/Malibu Village -PCH &Cross Creek	11,000	95%	10,450	3.0	<5	mostly sand	10%	2.7	0.24
Commercial - 16 Business Facilities	51,598		40,947						14.19
Residential 2 homes	800	95%	760	45.0				45.0	0.29
Total									14.5

Sector 4	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Malibu Rd., LLC -23676-23712 Malibu Rd	1,000	1%	10	40.0	<10	sand, silt & clay	20%	32.0	0.00
Morton-Gerson -23730 Malibu Rd	150	1%	2	40.0	<10	sand, silt & clay	20%	32.0	0.00
L.A. Co. Fire Station #88 -23720 Malibu Rd	540	1%	5	30.0	<10	sand, silt & clay	20%	24.0	0.00
Lisa Krasnoff -23655 Malibu Colony Rd	400	1%	4	40.0	<10	sand & silt	0%	40.0	0.00
Mesa, LLC 23915 PCH	400	1%	4	40.0	ukn.	ukn.	0%	40.0	0.00
Commercial - 5 Business Facilities	2,490		25						0.01
73 of 223 Res.@50% Flow to Lagoon	25,900	45%	11,655	45.0				45.0	4.38
150 of 223 Res.@20%Flow toLagoon	52,300	1%	523	45.0				45.0	0.20
Total									4.58

Sector 5	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Surfrider Co. Beach -23060 PCH	3,188	10%	319	40.0	>10	mostly beach sand	0%	40.0	0.11
Malibu Pier State Park -23000 PCH	3,000	1%	30	11.7	<10	mostly sand	10%	10.5	0.00
Malibu Shores Motel -23033 PCH	1,797	1%	18	60.0	10	sand & silt	10%	54.0	0.01
Malibu Beach Inn -22878 PCH	2,843	1%	28	31.9	<10	mostly sand	0%	31.9	0.01
Jack-in-the-Box -23017 PCH	1,800	1%	18	26.3	>10	fill, sand & silt	20%	21.0	0.00
Malibu Plaza 22917 PCH	1,500	1%	15	40.0	~ 10	fill, sand & silt	0%	40.0	0.01
Malibu Inn & Restaurant^ 22969 PCH	6,200	1%	62	110.0	~10	sand, silt & clay	0%	110.0	0.06
Surfshack/Fish Grill -22935 PCH	400	1%	4	80.0	~10	fill, sand & silt	0%	80.0	0.00
Spic & Span Cleaners/Chabad -22941 PCH	1,000	1%	10	40.0	~10	fill, sand & silt	0%	40.0	0.00
Commercial - 9 Business Facilities	20,328		504						0.20
Residential 23 homes	9,600	1%	96	45.0				45.0	0.04
Total									0.23

Study Area	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Commercial	127,241		44,575						15.67
Residential	139,300		51,299						19.26
Total	**266,541**		**95,874**						**34.93**

Table 4 Monitoring results of TN/BOD ratio of mixed usage commercial sources

#	Location	Date	Parameter	TN	BOD	TN/BOD
1	Malibu Colony Plaza	03/30/01	Composite	54.2	420	12.9%
2	Malibu Colony Plaza	04/30/01	Composite	49.6	332	14.9%
3	Malibu Colony Plaza	05/23/01	Composite	56.0	772	7.3%
4	Malibu Colony Plaza	07/27/01	Composite	70.5	552	12.8%
5	Malibu Colony Plaza	08/22/01	Composite	72.8	551	13.2%
6	Malibu Colony Plaza	09/07/01	Composite	65.3	705	9.3%
7	Malibu Colony Plaza	09/21/01	Composite	55.1	385	14.3%
8	Malibu Colony Plaza	09/28/01	Composite	72.8	635	11.4%
9	Malibu Colony Plaza	10/05/01	Composite	67.2	477	14.1%
10	Malibu Colony Plaza	10/12/01	Composite	60.7	491	12.4%
11	Malibu Colony Plaza	10/19/01	Composite	65.3	34	192.1%
12	Malibu Colony Plaza	10/26/01	Composite	56.0	542	10.3%
13	Malibu Colony Plaza	11/02/01	Composite	56.0	383	14.6%
14	Malibu Colony Plaza	11/09/01	Composite	53.7	441	12.2%
15	Malibu Colony Plaza	11/17/01	Composite	44.7	359	12.5%
16	Malibu Colony Plaza	12/29/01	Composite	62.3	279	22.3%
	Malibu Colony Plaza	**2001 Yearly**	**Composite**	**60.1**	**460.0**	**24.2%**
17	Malibu Colony Plaza	01/11/02	Composite	18.1	386	4.7%
18	Malibu Colony Plaza	02/15/02	Composite	38.4	539	7.1%
19	Malibu Colony Plaza	03/14/02	Composite	69.4	424	16.4%
20	Malibu Colony Plaza	04/16/02	Composite	25.3	201	12.6%
21	Malibu Colony Plaza	05/17/02	Composite	18.7	592	3.2%
22	Malibu Colony Plaza	06/21/02	Composite	60.7	461	13.2%
23	Malibu Colony Plaza	07/19/02	Composite	45.5	210	21.7%
24	Malibu Colony Plaza	08/15/02	Composite	68.4	566	12.1%
25	Malibu Colony Plaza	09/26/02	Composite	41.0	359	10.8%
26	Malibu Colony Plaza	10/17/02	Composite	43.9	344	12.8%
27	Malibu Colony Plaza	11/12/02	Composite	60.4	384	15.7%
28	Malibu Colony Plaza	12/19/02	Composite	60.5	394	15.4%
	Malibu Colony Plaza	**2002 Yearly**	**Composite**	**45.9**	**406.7**	**12.1%**
29	Malibu Colony Plaza	01/22/03	Composite	48.4	515	9.4%
30	Malibu Colony Plaza	02/21/03	Composite	45.6	291	15.7%
31	Malibu Colony Plaza	03/27/03	Composite	35.8	318	11.3%
32	Malibu Colony Plaza	04/24/03	Composite	61.2	346	17.7%
33	Malibu Colony Plaza	05/27/03	Composite	62.1	641	9.7%
34	Malibu Colony Plaza	06/10/03	Composite	40.3	334	12.1%
35	Malibu Colony Plaza	07/17/03	Composite	54.7	286	19.1%
36	Malibu Colony Plaza	08/14/03	Composite	64.9	308	21.1%
35	Malibu Colony Plaza	09/18/03	Composite	55.8	469	11.9%
38	Malibu Colony Plaza	10/16/03	Composite	51.3	431	11.9%
39	Malibu Colony Plaza	11/19/03	Composite	81.3	441	18.4%
40	Malibu Colony Plaza	12/17/03	Composite	68.1	402	16.9%

	Malibu Colony Plaza	**2003 Yearly**	**Composite**	**55.8**	**398.5**	**14.6%**
41	Malibu Colony Plaza	01/15/04	Composite	35.8	250	14.3%
42	Malibu Colony Plaza	02/19/04	Composite	35.4	288	13.0%
43	Malibu Colony Plaza	03/11/04	Composite	47.6	403	11.8%
44	Malibu Colony Plaza	04/08/04	Composite	43.2	410	10.5%
45	Malibu Colony Plaza	08/12/04	Composite	70.2	344	20.4%
46	Malibu Colony Plaza	11/18/04	Composite	45.5	466	9.8%
	Malibu Colony Plaza	**2004 Yearly**	**Composite**	**46.6**	**360.2**	**13.3%**
47	Malibu Colony Plaza	02/24/05	Composite	19.0	91	20.8%
48	Malibu Colony Plaza	05/13/05	Composite	58.0	617	9.4%
49	Malibu Colony Plaza	08/12/05	Composite	82.1	483	17.0%
50	Malibu Colony Plaza	11/10/05	Composite	101.7	287	35.4%
	Malibu Colony Plaza	**2005 Yearly**	**Composite**	**65.2**	**369.5**	**20.7%**
51	Malibu Creek Plaza	01/30/02	Single Sample	53.5	352	15.2%
52	Malibu Creek Plaza	02/28/02	Single Sample	33.9	122	27.8%
53	Malibu Creek Plaza	03/14/02	Single Sample	25.6	177	14.5%
54	Malibu Creek Plaza	04/16/02	Single Sample	15.5	62	25.0%
55	Malibu Creek Plaza	05/17/02	Single Sample	12.7	141	9.0%
56	Malibu Creek Plaza	06/21/02	Single Sample	30.5	64	47.7%
57	Malibu Creek Plaza	07/19/02	Single Sample	25.3	181	14.0%
58	Malibu Creek Plaza	08/15/02	Single Sample	49.6	147	33.7%
59	Malibu Creek Plaza	09/26/02	Single Sample	20.8	136	15.3%
60	Malibu Creek Plaza	10/17/02	Single Sample	30.8	148	20.8%
61	Malibu Creek Plaza	11/12/02	Single Sample	47.5	191	24.9%
62	Malibu Creek Plaza	12/19/02	Single Sample	42.2	127	33.2%
	Malibu Creek Plaza	**2002 Yearly**	**Single Sample**	**32.3**	**154.0**	**23.4%**
63	Malibu Creek Plaza	01/22/03	Single Sample	41.5	214	19.4%
64	Malibu Creek Plaza	02/21/03	Single Sample	43.4	133	32.6%
65	Malibu Creek Plaza	03/27/03	Single Sample	35.0	152	24.3%
66	Malibu Creek Plaza	04/24/03	Single Sample	39.2	142	27.6%
67	Malibu Creek Plaza	05/27/03	Single Sample	45.9	207	22.2%
68	Malibu Creek Plaza	06/10/03	Single Sample	32.8	171	19.2%
69	Malibu Creek Plaza	07/17/03	Single Sample	7.6	22	34.7%
70	Malibu Creek Plaza	08/14/03	Single Sample	44.1	133	33.2%
71	Malibu Creek Plaza	09/18/03	Single Sample	51.7	161	32.1%
72	Malibu Creek Plaza	10/15/03	Single Sample	38.0	129	29.4%
73	Malibu Creek Plaza	11/19/03	Single Sample	45.9	113	40.6%
74	Malibu Creek Plaza	12/17/03	Single Sample	35.3	82	43.0%
	Malibu Creek Plaza	**2003 Yearly**	**Single Sample**	**38.5**	**138.3**	**29.8%**
75	Malibu Creek Plaza	01/15/04	Single Sample	33.2	117	28.4%
76	Malibu Creek Plaza	02/19/04	Single Sample	28.9	147	19.6%
77	Malibu Creek Plaza	03/11/04	Single Sample	42.3	148	28.6%
78	Malibu Creek Plaza	04/08/04	Single Sample	33.7	142	23.7%
79	Malibu Creek Plaza	05/27/04	Single Sample	42.3	151	28.0%
80	Malibu Creek Plaza	06/17/04	Single Sample	64.9	145	44.8%

81	Malibu Creek Plaza	07/22/04	Single Sample	42.7	205	20.8%
82	Malibu Creek Plaza	08/12/04	Single Sample	56.1	131	42.8%
83	Malibu Creek Plaza	09/09/04	Single Sample	41.7	143	29.2%
84	Malibu Creek Plaza	10/14/04	Single Sample	55.6	116	47.9%
85	Malibu Creek Plaza	11/18/04	Single Sample	45.1	145	31.1%
86	Malibu Creek Plaza	12/16/04	Single Sample	53.9	92	58.6%
	Malibu Creek Plaza	**2004 Yearly**	**Single Sample**	**45.0**	**140.2**	**33.6%**
87	Malibu Creek Plaza	01/13/05	Single Sample	35.39	164	21.6%
88	Malibu Creek Plaza	02/24/05	Single Sample	9.3	56	16.6%
89	Malibu Creek Plaza	03/04/05	Single Sample	23.81	79	30.1%
90	Malibu Creek Plaza	04/14/05	Single Sample	44.8	162	27.7%
91	Malibu Creek Plaza	May	Single Sample	31.97	140	22.8%
92	Malibu Creek Plaza	June	Single Sample	19.91	82	24.3%
93	Malibu Creek Plaza	07/21/05	Single Sample	22.64	132	17.2%
94	Malibu Creek Plaza	Aug	Single Sample	39.55	149	26.5%
95	Malibu Creek Plaza	Sept	Single Sample	35.82	160	22.4%
96	Malibu Creek Plaza	10/20/05	Single Sample	40.2	125	32.2%
97	Malibu Creek Plaza	11/10/05	Single Sample	27.94	188	14.9%
98	Malibu Creek Plaza	12/22/05	Single Sample	83.11	156	53.3%
	Malibu Creek Plaza	**2005 Yearly**	**Single Sample**	**34.5**	**132.8**	**25.8%**
99	Malibu Country Mart I	06/15/00	Single Sample	29.4	355	8.3%
100	Malibu Country Mart I	06/15/00	Single Sample	101.0	207	48.8%
101	Malibu Country Mart I	06/15/00	Single Sample	66.2	2853	2.3%
102	Malibu Country Mart I	06/15/00	Single Sample	75	897	8.3%
103	Malibu Country Mart I	06/15/00	Single Sample	70.5	882	8.0%
104	Malibu Country Mart I	06/15/00	Single Sample	70.9	935	7.6%
	Malibu Country Mart I	**2000 Yearly**	**Single Sample**	**68.8**	**1021.5**	**13.9%**
105	Malibu Country Mart II	06/15/00	Single Sample	77.0	1098	7.0%
106	Malibu Country Mart II	06/15/00	Single Sample	77.9	403	19.3%
	Malibu Country Mart II	**2000 Yearly**	**Single Sample**	**77.5**	**750.5**	**13.2%**
				Average		**20.4%**

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

Attachment 4-1

Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loadings from OWDS to the Lagoon

C.P. Lai, Ph.D., P.E.

This memorandum summarizes the findings of previous studies on the mass loadings of nitrogen to Malibu Lagoon from on-site wastewater disposal systems (OWDS). Using recent data, staff then estimated the nitrogen loading into Malibu Lagoon based on previous numerical modeling results and a spread sheet model. Finally, staff estimated the nitrogen concentration in Lagoon water resulting from this mass loading by using a continuous stirred tank reactor (CSTR) mass balance model.

1.0 Briefing of Previous Studies

Three previous studies about the subject topics have been reviewed and their estimates of mass loadings of nitrogen at the edge of the Lagoon are summarized as follows:

1.1 Stone Report
(Groundwater-Flow and Solute Transport Modeling as Appendix 3 of the Final Report "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", August 2004)

A numerical model was used to simulate groundwater flow and solute transport in the alluvium deposited along Malibu Creek and Lagoon near the Malibu Civic Center area. The groundwater flow model used in this study is the USGS MODFLOW model and the solute transport model is the USEPA MT3D groundwater transport model. The model is limited by the amount of data that was used to build, calibrate, and verify the model.

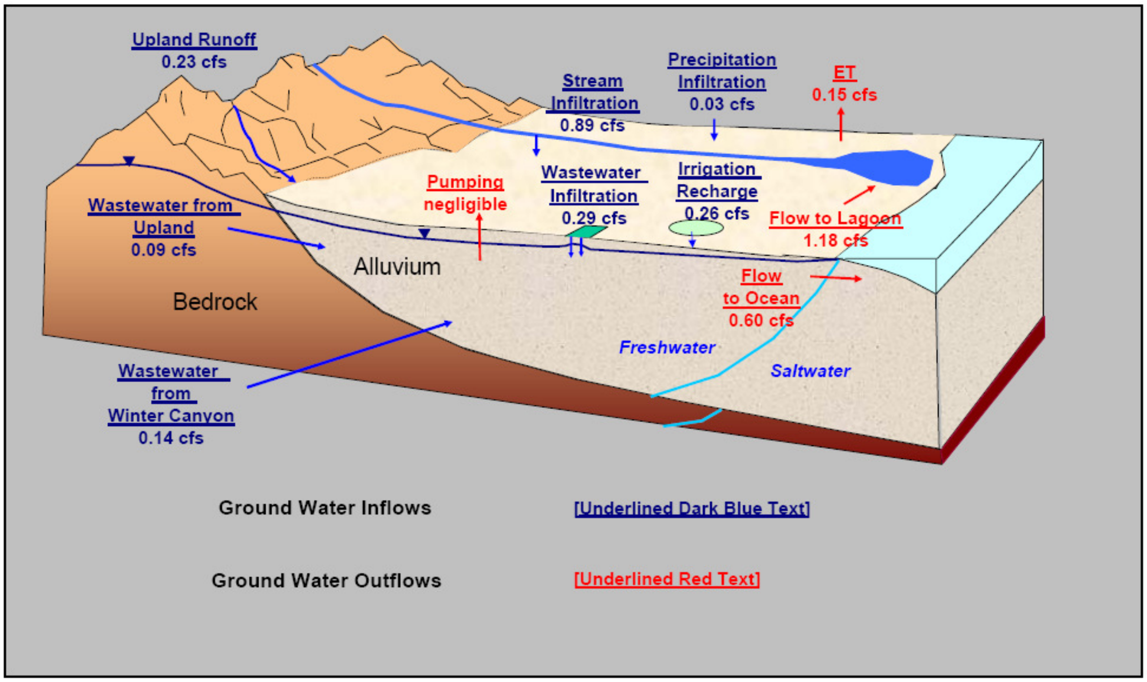
The purposes for constructing a model for the Malibu Civic Center area were to develop a water budget, to determine directions of groundwater flow, to identify which parts of the study area contribute groundwater flow to the beaches and to Malibu Lagoon, to estimate how long it takes groundwater from various parts of the study area to reach the beaches and Malibu Lagoon, and to estimate how much nitrogen is transported by the groundwater from OWDS to the Lagoon and to the ocean. No attempt was made in this model to estimate the mass loading for bacteria.

Results from the flow modeling were used to evaluate directions of groundwater flow, groundwater travel times in the flow system, and the contributing area for the Lagoon and ocean. The transport simulation was run for the period from 1930 through 2090, for a total of 160 years.

The total amount of wastewater disposal assumed as input for the model is approximately 0.52 cubic feet per second (cfs). Commercial wastewater disposal is estimated to be about 0.115 cfs. Source concentrations of nitrogen from OWDS were assumed to be 20 mg/l from domestic wastewater disposal systems and 50 mg/l from commercial systems.

The total average annual inflow to the alluvial groundwater flow system was estimated and is presented in Figure 1 below. The estimated total annual inflow to the alluvial groundwater flow system is approximately 1.93 cfs. The estimated total annual outflow is also 1.93 cfs, which includes 1.18 cfs to Malibu Lagoon, 0.60 cfs to the Pacific Ocean and 0.15 cfs for evapotranspiration.

Figure 1 Average Annual Groundwater Budget for the Malibu Alluvium



Transport model simulations were run with four steady-state hydraulic stresses, which represent changing source loadings over different time periods, for un-breached and breached Lagoon conditions in order to estimate nitrogen loadings to the ocean and Lagoon from OWDS. Depending upon the assumptions of nitrate degradation, the calculated maximum nitrogen loading to the Lagoon resulting from OWDS ranges from 31 lbs/day (un-breached Lagoon with no degradation) to 11 lbs/day (breached Lagoon with a 2-year half life). The calculated nitrogen mass loading rates to the Malibu Lagoon and the ocean under the breached Lagoon condition are shown in Figure 2. Figure 2 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Additionally, the study modeled groundwater movement to determine the time of travel to Malibu Creek, Malibu Lagoon, the surf zone, and the ocean. Some areas had times of travel as short as six months and others as long as 50 years.

Figure 2 Calculated Nitrogen Loading Rates to the Malibu Lagoon and the Ocean under the Breached Condition

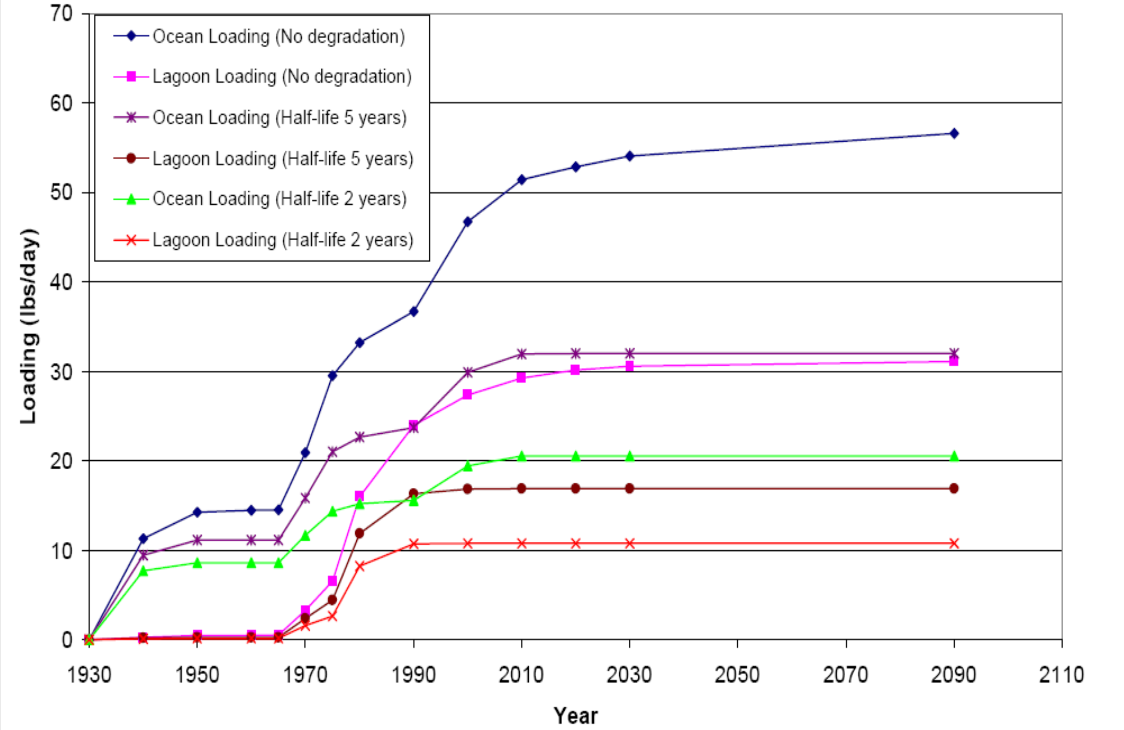


Figure 30 - Nitrate loading rates to the ocean and lagoon under breached lagoon conditions, with no degredation, five-year half life and two-year half life.

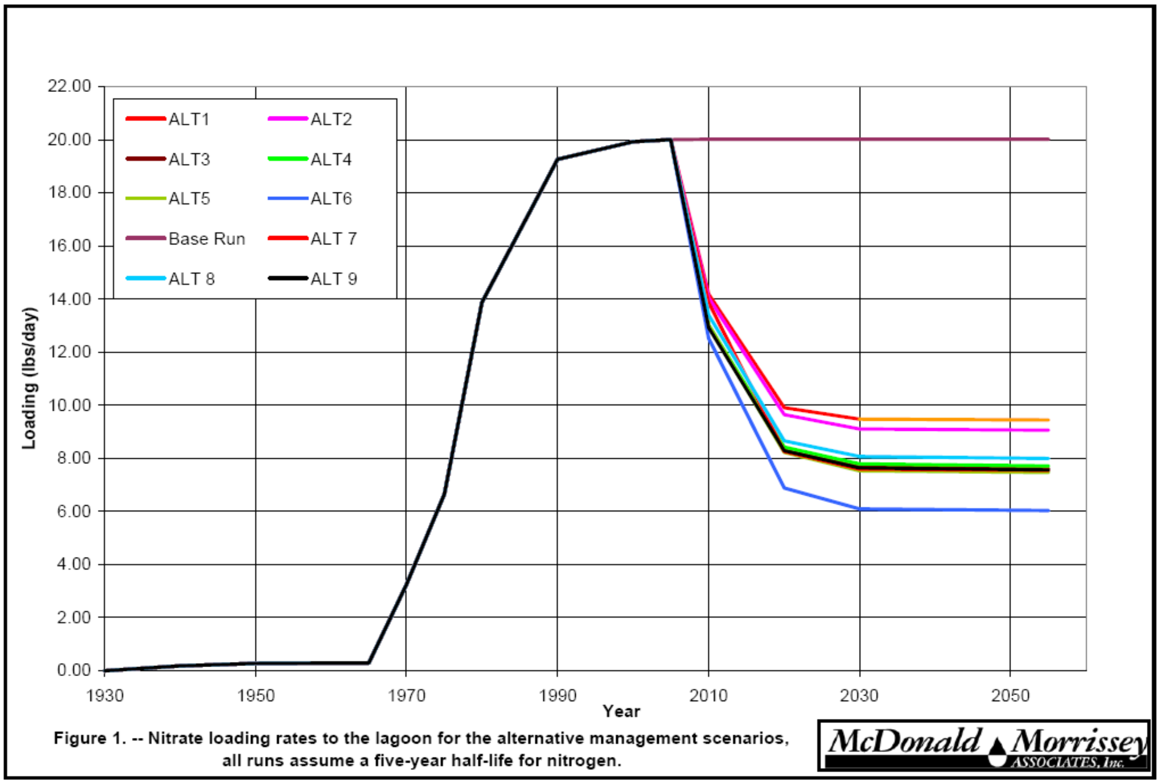
1.2. Questa Report

(Groundwater Modeling Report as Appendix D of the Final Report "Civic Center Integrated Water Quality Management Feasibility Study for City of Malibu", April 2005)

The three-dimensional groundwater flow and solute transport model developed for the Risk Assessment study (the Stone Report) was refined by McDonald Morrissey Associates to assess the potential water quality implications of various combinations of wastewater collection, treatment and dispersal options. Nine options were evaluated along with a baseline condition. Estimated wastewater flows from future development, as well as existing wastewater flows, were considered in the analysis. The model results of nitrogen mass loadings into the Malibu Lagoon for each wastewater management alternative, including the existing condition, are shown in Figure 3.

The nitrogen load at the present condition was estimated to be approximately 20 lbs/day. This result is slightly greater than the result obtained in the Stone Report (17 lbs/day) because additional loading from commercial OWDS was included. Figure 3 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Figure 3 Calculated Nitrogen Loading Rates to the Malibu Lagoon for the Alternative



Management Scenarios

1.3 Tetra Tech Report
(Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies, December 2002)

The TMDL modeling report estimated that nitrogen loading from residential OWDS is 59.2 milligram/liter (mg/l) with 274 gallons per day (gpd) average effluent flow rate. It also assumed that there are two billion coliform counts per person per day discharged into OWDS, and an average population of 3.4 persons per household.

For "normal" OWDS, the TMDL report assumed 100% of the bacteria load is removed prior to reaching surface water bodies, and that 50% of the nitrogen loading reaches the surface water (TetraTech, 2002). For the "failed" OWDS, it was assumed that 40% of the bacteria reaches the Lagoon and 50% of the nitrogen reaches the Lagoon. For "short circuited" systems, 87% of the nitrogen loads and 20% of the bacteria loads were assumed to enter the Lagoon.

Based on the above assumptions, TetraTech (2002) estimated the current total annual bacteria load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 1,176,760 x 10^9 counts per year (3,224 x10^9 counts per day) for fecal coliform.

Similarly, the report estimated the current total annual nitrogen load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 23,434 pounds per year, or 64.2 lb/day (TetraTech, 2002).

2.0 Staff Estimate of Mass Loading Rates into the Malibu Lagoon

2.1 Estimate using Questa Numerical Model Results

The Questa groundwater flow and transport modeling assumed that the unsaturated zone had a negligible effect on nitrogen species and that the tidal actions and influences had a negligible effect on the water table and solute transport. Based on local soil properties, the soil is mostly sand and less clay. As such, the assumption that infiltration flows directly into the saturated zone is reasonable. As far as tidal influences are concerned, the varied tidal level will slightly affect the local water table and will not have much of an effect on the up-gradient groundwater water elevation. Therefore, staff concludes that the model results obtained from the Questa Report can be used to estimate the nitrogen mass loading to the Malibu Lagoon using recent OWDS loading data.

From Figure 2, it can be seen that the maximum loading rate to the Malibu Lagoon for the breached Lagoon condition varies from 31 lbs/day (no degradation) to 17 lbs/day (5-year half life) depending on different nitrate degradation coefficients. To be conservative, staff assumed the breached condition and a 5-year half life for the nitrate degradation rate to estimate nitrogen mass loading to the Malibu Lagoon. The relationship of nitrogen mass loading from OWDS and mass loading entering the Lagoon from the Questa Report is presented in Figure 4. There are four loading periods shown in Figure 4 to represent general changes in rates of mass loading into the Lagoon based on changes in source loading to the groundwater system. The loading period A is the period during 1930 to 1964 in which the simulated sources were from Malibu Colony only. During loading period B from 1965 to 1974, the simulated source loading includes the additional loading from residential areas in uplands adjacent to the alluvium. The loading period C from 1975 to 1989 includes all sources in loading period B plus commercial systems in the main body of alluvium. For the loading period D from 1990 to 2009, the source loading includes all sources in the loading period C plus loading from increased commercial and wastewater disposal at the Malibu Bay Colony plant.

To estimate the current loading to the Malibu Lagoon, the flow rate and concentration of wastewater from OWDS for commercial and residential areas from 2008-2009 were used to calculate the mass loading from OWDS to groundwater in the study area and then, based on the relationship for the loading period D as shown in Figure 4, to estimate the mass loading of nitrogen to the Malibu Lagoon. The resulting estimate of nitrogen mass loading into the Lagoon is 30.2 lbs/day based on mass loading from OWDS of 94.4 lbs/day as shown in Table 1.

2.2 Estimate using Spread Sheet Model

Since there are no numerical model input data available, the estimate of mass loading into the Lagoon assumes that the relationship between mass loading from OWDS and mass loading to the Lagoon is linear and the ratio of mass loading of 0.32 obtained from the Questa Report was used. However, the relationship between mass loading from OWDS and mass loading into the Lagoon may not be linear because the increased mass loading from OWDS could contribute more mass loading into the Lagoon due to the limited nitrogen capacity of groundwater during long term discharge and the effect of local groundwater flow net patterns. As such, Regional Board staff in the Groundwater Permitting Unit used a spread sheet model to estimate the mass loading entering the Lagoon based on local geotechnical data, hydraulic conductivity and groundwater flow net patterns. The estimate of mass loading into the Lagoon based on this spread sheet model is **34.9** lbs/day resulting from a mass loading from OWDS of 94.4 lbs/day.

The comparisons of the three previous modeling results and staff estimates of nitrogen mass loading to the Malibu Lagoon using a numerical model and a spreadsheet model are presented in Table 1.

2.3 Evaluation of Nitrogen Mass Loadings into the Lagoon using a Mass Balance Model

To evaluate which estimate of mass loading to the Lagoon presented in Table 1 is the best fit with actual conditions and to understand the effect of mass loading from OWDS to the Malibu Lagoon on nitrogen concentrations in Lagoon water, staff used a continuous stirred tank reactor (CSTR) mass balance model to estimate the resulting concentration due to the mass loading. The CSTR model results for different mass loadings are presented in Figure 5. The results are compared with actual Lagoon nitrogen concentration data. It can be seen from Figure 5 that the predicted nitrogen concentration in the Lagoon due to a mass loading entering the Lagoon of 20 lbs/day (as predicted by the Questa Report) is a good comparison with the average nitrogen concentration of 1.4 mg/L for receiving water data collected by the Tapia wastewater treatment plant from 1995-1999. In addition, the predicted nitrogen concentration due to the load allocations for OWDS developed in the TMDL of 6 lbs/day is less than the nitrogen numeric target of 1.0 mg/L. The maximum of nitrogen mass loading into the Lagoon to maintain the nitrogen numeric target of 1.0 mg/L is about 13 lbs/day.

Staff estimates that the current mass loading into the Lagoon from OWDS may vary from 30 lbs/day to 35 lbs/day based on the predicted nitrogen concentrations in the Lagoon water and measured Lagoon nitrogen concentrations for 2002-2003 data (SCCWRP Technical Report 441) as shown in Figure 5. The current estimate of mass loading into the Lagoon of 34.9 lb/day using the spread sheet method would produce a nitrogen concentration in the Lagoon water of 2.9 mg/L and the current estimate of mass loading of 30.2 lb/day using the Questa numerical model results would cause the nitrogen concentration in the Lagoon water to be 2.5 mg/L. According to the measured data during 1995-1999 and 2002-2003, the nitrogen concentration in the Lagoon water is increasing. As such, the resulting nitrogen concentration of 2.9 mg/L for 2008-2009 falls within the trend of measured data from 1995 to 2003. Thus, the mass loading into the Lagoon of 34.9 lb/day is considered to be an appropriate and reasonable estimate.

In summary, staff finds that the previous model developed by McDonald Morrissey Associates as presented in the Questa Report was calibrated with measured nitrate data and its modeling results can be used and have been used in this memo to estimate current nitrogen mass loading into the Lagoon. The spreadsheet model also provides a reasonable estimate of current mass loading to the Lagoon. By comparing the results of these two models with measured nitrogen concentration data in the Lagoon, staff estimates that **29-35** lbs/day of nitrogen are loaded to the lagoon, which exceeds the TMDL load allocation and results in exceedances of the TMDL numeric target.

3.0 References

1. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Final Report, prepared for Santa Monica Bay Restoration Commission, prepared by Stone Environmental, Inc., August 30, 2004.
2. "Ground-Water Flow and Solute Transport Modeling, Malibu, California", prepared for Santa Monica Bay Restoration Project, prepared by McDonald Morrissey Associates Inc., July 28, 2004.
3. "Malibu Civic Center Integrated Water Quality Management Feasibility Study", prepared for City of Malibu, prepared by Questa Engineering Corporation, April 28, 2005.
4. "Groundwater Modeling Report in the Appendix D of Malibu Civic Integrated Water Quality Management Feasibility Study", prepared by McDonald Morrissey Associates, Inc., April 26, 2005.
5. "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", United States Environmental Protection Agency, Region 9, 2003.
6. "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development", prepared for Sterling Capitol, prepared by Furgo West, Inc., March 2005.
7. "Final Malibu Lagoon Restoration and Enhancement Plan", prepared for the California State Coastal Conservancy & California State Department of Parks and Recreation, prepared by Moffatt & Nichol, June 17, 2005.
8. "Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon", prepared for City of Malibu, prepared by RMC, March 26, 2008.
9. "Lower Malibu Creek and Lagoon Resource Enhancement and Management ", Final Report to the California State Coastal Conservancy, prepared by Richard F. Ambrose and Antony R. Orme, University of California, Los Angeles, May 2000.
10. "Malibu Wetland Feasibility Study", prepared for Malibu Coastal Land Conservation, prepared by Huffman and Carpenter, Inc., August 2000.
11. "Sediments as a Non-Point Source of Nutrients to Malibu Lagoon, California, USA", Southern California Coastal Water Resources Project (SCCWRP) Technical Report 441, October 2004.
12. Las Virgenes Municipal Water District (LVMWD),Tapia Water Reclamation Facilities, Malibu Creek Monitoring Program, 1995-1999 Annual Report, NPDES Permit No. CA0056014.

Figure 4 Relationship of nitrogen mass loading from OWDS and mass loading into the Lagoon

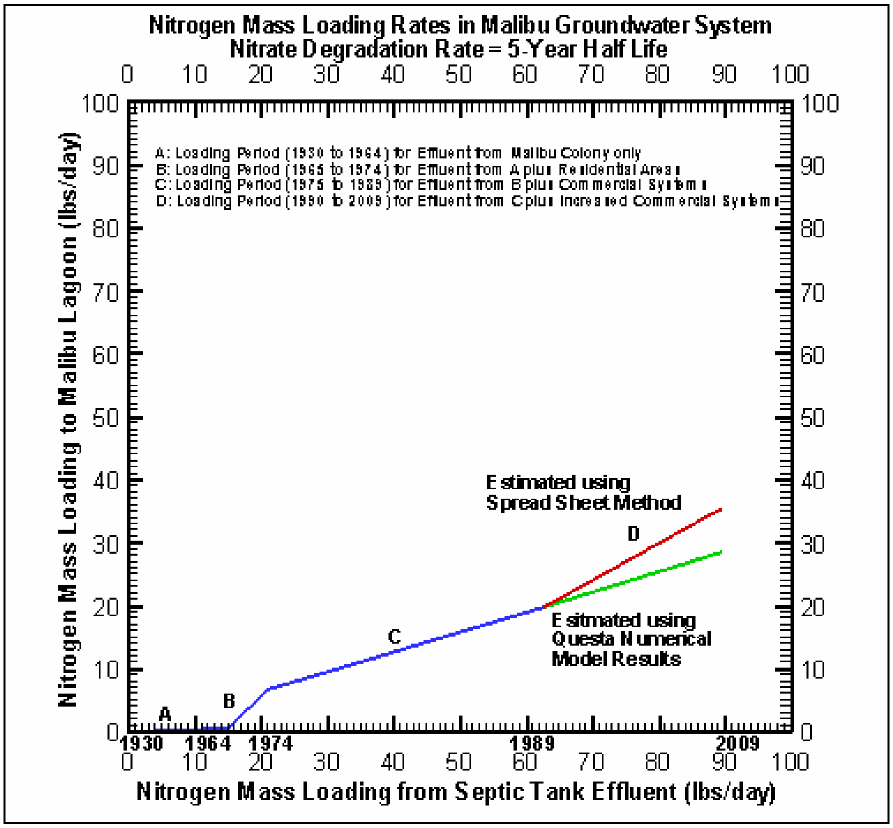


Table 1 Comparisons of nitrogen mass loading to the Malibu Lagoon for three previous studies and staff estimates

	Stone Report (2004)[b]	Questa Report (2005)[b]	Tetra Tech Report (2003)[c]	Staff Estimate Using Spread Sheet Method[d]	Staff Estimate Using Numerical Model Method[e]
1.Wastewater Flow Rate from Commercial OWDS (gal/day)	62166	100000	75000	127241	127241
2.Concentration in Commercial Wastewater (mg/L)	50	50	59.2	3 - 110	3 – 110
3.Mass Loading from Commercial OWDS (lbs/day)	25.94	41.73	37.05	42.1	42.1
4.Wastewater Flow Rate from Residential OWDS (gal/day)	126121	126121	54800	139300	139300
5.Concentration in Residential Wastewater (mg/L)	20	20	59.2	45	45
6.Mass Loading from Residential OWDS (lbs/day)	21.05	21.05	27.07	52.3	52.3
7.Mass Loading from OWDS (lbs/day)	46.99	62.78	64.12	94.4	94.4
8.Ratio of Mass Loading[a]	0.36	0.32	0.50	0.38	0.32
9.Mass Loading to Malibu Lagoon(lbs/day)	17	20	32	34.9	30.2

Note: [a] the ratio of mass loading entering Malibu Lagoon versus mass loading from OWDS, i.e., value of row 9 divided by value of row 7.

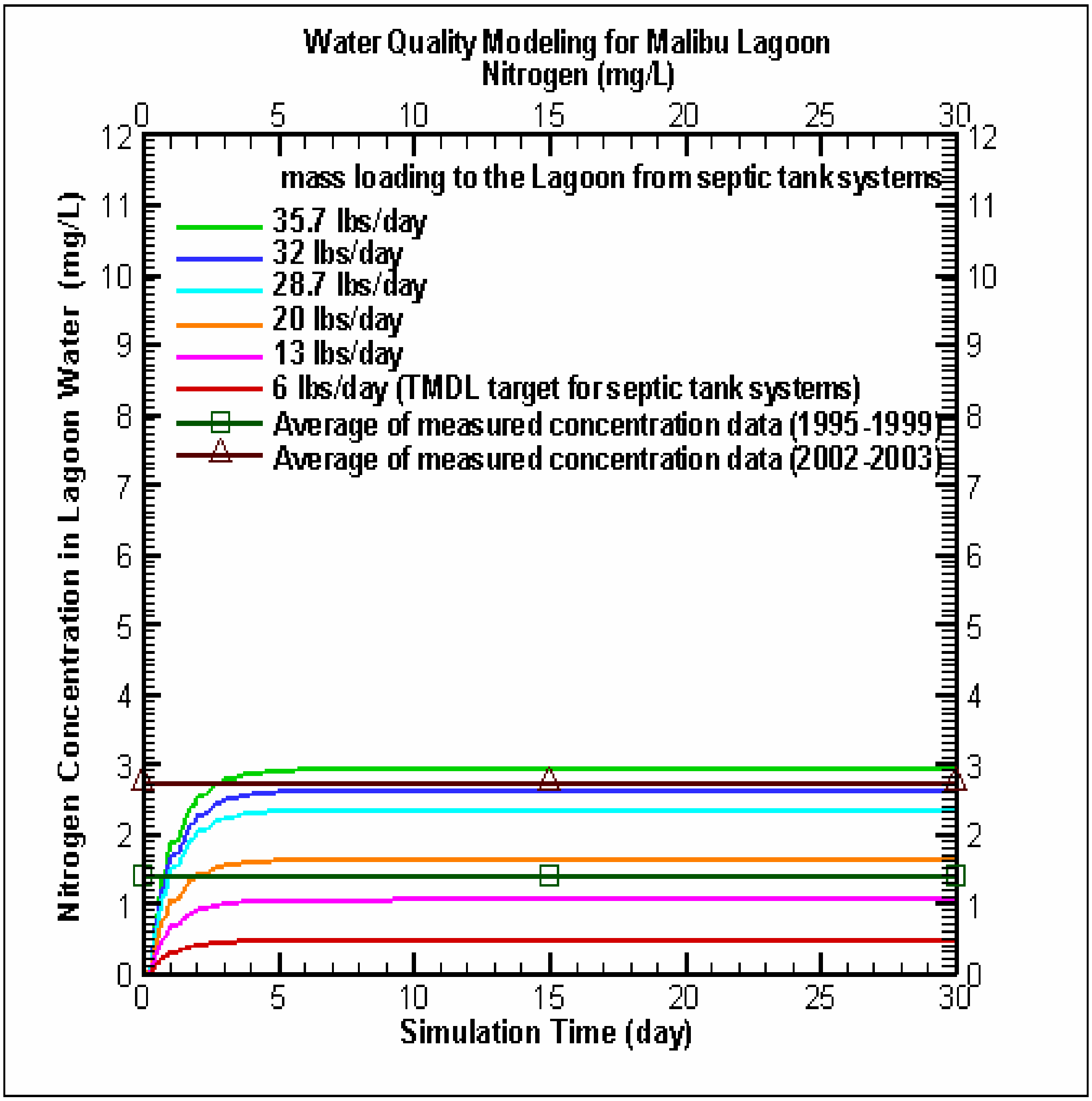
[b] the nitrogen loads were assumed to be mostly nitrate in the OWDS and the model only simulated the nitrate in the Stone and Questa Modeling Reports.

[c] 50 percent of nitrogen loads from the OWDS were assumed to enter the Malibu Lagoon.

[d] the nitrogen mass loading from OWDS was estimated based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L for OWDS. Staff estimated the nitrogen mass loading to Malibu Lagoon by using the spread sheet method.

[e] the nitrogen mass loading based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L from OWDS were used in the model. Staff estimated the nitrogen mass loading to Malibu Lagoon by using Questa numerical model results.

Figure 5 Nitrogen concentrations in Lagoon water resulting from different mass loadings entering the Lagoon



State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review – Staff Memorandum

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Toni Callaway, P.G., Engineering Geologist

November 5, 2009

California Regional Water Quality Control Board
Los Angeles Region

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Cal/EPA Secretary

Arnold Schwarzenegger
Governor

Date: October 21, 2009

To: Rebecca Chou, Ph.D., P.E., Chief of Groundwater Permitting Unit
Wendy Phillips, PG, CHG, CEG, Chief of Groundwater Permitting and Landfill Section

From: Toni Callaway, P.G., Engineering Geologist, Groundwater Permitting Unit

Subject: **Peer Review Response to Comments - Technical Memorandum #4: Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life**

Attachments:

1. Comment dated September 5, 2009 from Dr. Robert Arnold of Arizona State University
2. Comments dated September 10, 2009 from Dr. Jörg Drewes of Colorado School of Mines
3. Comments dated September 12, 2009 from Dr. JoAnn Silverstein of the University of Colorado at Boulder

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To ensure that the proposed amendment to the *Basin Plan*[1] is based on sound science and engineering principles, the scientific elements of Technical Memorandum (Tech Memo) #4: *Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life,* draft dated August 5, 2009 (Tech Memo #4), were peer reviewed. This peer review was conducted in accordance with requirements and guidelines from the Cal/EPA Scientific Peer Review Program, Office of Research, Planning and Performance.

All three peer reviewers responded promptly and provided valuable comments. In summary, all three peer reviewers found that the basic approaches and methods used to calculate the nitrogen loading to Malibu Lagoon in Tech Memo #4 incorporated sound scientific and engineering principles.

Suggestions were made to clarify the assumptions made by staff. Staff responded to these suggestions and revised Tech Memo #4 as appropriate and noted that none of the changes materially altered the conclusion of Tech Memo #4. That is: On-site subsurface disposal systems (OWDSs) in the Malibu Civic Center area cumulatively release nitrogen to Malibu Lagoon at

[1] Proposed amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to prohibit on-site subsurface disposal systems (OWDSs) in the Malibu Civic Center area.

rates that violated the total maximum daily limit (TMDL) adopted by the US Environmental Protection Agency in 2003 for the Malibu Lagoon (USEPA, 2003).

Comments have been summarized into three main issues and presented in *italics*, followed by staff's response. The main issues raised in the comments are: 1) Residential Loading - Is the 100 gallons per day per person (gpd/person) wastewater flow rate assumed in the Tech Memo for single-family homes realistic? 2) Commercial Loading - Are the flow rates estimated for un-permitted commercial properties in the Tech Memo accurate? and 3) TN/BOD Ratio - Is the TN/BOD Ratio of 0.20 in wastewater used in the Tech Memo an appropriate estimation for total nitrogen (TN) when biochemical oxygen demand (BOD_5) data is available while TN data is not available? Comments related to these issues are addressed in paragraphs 1 through 3 below:

1. ***Residential Loadings**: Comparing to the typical rate of wastewater generation per capital in the literature (40 to 90 gpd/person), the 100 gpd/person rate used in Tech Memo #4 for the Malibu Civic Center area may be too high.*

   Staff considers the residences in the Malibu Civic Center area luxury homes, because almost all the 392 residences in the area are large single family homes with more than 3.5 bath/bedrooms per house. Many studies have shown that luxury homes use more water than ordinary homes and therefore generate more wastewater. For example, Metcalf and Eddy (1991, Table 2-9, page 27) reported that the average water usage for luxury homes in residential areas was 75-150 gpd/person, while the water usage for the average home nationwide was 70 gpd/person. The higher than typical wastewater flow rate used in Tech Memo #4 is also supported by historical water use data of Malibu City. In 2008, the population of the Malibu City was 13,009 and the water consumption of the City was 2,200 million gallons for both commercial and residential usage. It has been estimated that approximately 54% of urban water usage is residential (Department of Water Resource in California) and that 50% of residential water usage is for irrigation (American Water Works Association). Assuming these percentages are applicable to the Malibu Civic Center area, the net per capita water consumption (excluding irrigation use) would be 125 gpd/person. Because the bulk of residential water consumption becomes wastewater at the end, the 100 gpd/person of wastewater flow rate used for the Malibu Civic Center area is a reasonable estimate. Tech Memo #4 has therefore not been modified in response to this comment.

2. ***Commercial Loading**: In Tech Memo #4, wastewater flow rates from small businesses were estimated using on-site population and business activity information. A few details or examples of the process by which wastewater flows were assigned might provide a feel for this work.*

A new column (category) has been added to Table 1 in Tech Memo #4 to characterize each commercial facility, including whether flow rate of the facility was estimated. New footnotes have also been added to Table 1 to better explain the data source for each facility. Of the 38 commercial facilities in the Malibu Civic Center area that discharge wastewater with OWDSs, the flow rates of 7 facilities were not available and had to be estimated. This constitutes 5.4% of the total commercial flow.

3. ***TN/BOD Ratio****: Staff assumed a constant fraction (0.20) of total nitrogen concentration to five-day biochemical oxygen demand (TN/BOD_5) to estimate nitrogen load of commercial sources where only BOD_5 measurements were available. More appropriate references should be used to provide the accurate representation of single source waste streams. TN/BOD ratios from single sources should be site-specific and highly depending on the types of dischargers (i.e. lower in restaurant effluents). If local data exist with which to make this distinction, they should be cited in the text. It is advisable that samples be taken to verify the TN:BOD ratio from specific dischargers with higher flow.*

BOD_5 is a measurement of the amount organic substances in wastewater. Because nitrogen in wastewater is mostly derived from organic substances (proteins), the concentration of total nitrogen generally increases with the increase of BOD_5. The 0.20 TN/BOD_5 ratio used in Tech Memo #4 is consistent with tables characterizing residential wastewater found in college textbooks, such as Metcalf and Eddy (1991) and Crites and Tchobanoglous (1998). Staff has added Table 4 which summarizes TN and BOD analytical data from 106 septic tank wastewater samples from large mixed usage commercial facilities located in the Malibu Civic Center area. The average TN/BOD_5 ratio for these samples was 20.4%, which is essentially the same as what was used in Tech Memo #4. The mixed use commercial properties include restaurants, but there are few stand-alone restaurant in the Malibu Civic Center area.

Staff responses to comments requiring minor clarification summarized in paragraphs A through H below:

A. Staff should provide more information regarding the OWDSs being used in the Malibu Civic Center area, such as a definition of "advanced" OWTS treatment. In the interest of defining the most significant sources of nitrogen load, the facilities that provide advanced treatment, the nature of the treatment provided, and typical BOD_5 and total nitrogen removal efficiencies might be added to the report. The credits between OWDSs and soil profile to the removal of nitrogen/BOD should be clarified.

"Advance OWTS treatment" is defined as more advanced than primary treatment, i.e. secondary and tertiary treatment with disinfection. The advanced systems in the Malibu

Civic Center area vary greatly, no two are alike, but a footnote (Footnote D) has been added to Table 1 to identify advanced OWTSs. As stated in Tech Memo #4, the Regional Board lacks site specific information for the hundreds of residential septic systems in the Malibu Civic Center area. When available, the effluent loads (nitrogen concentration) in Table 1 listed real "end-of-pipe" data.

In Table 3 of Tech Memo #4, credits for TN reduction in the soil profile are based on soil type (e.g. sandy loam), sufficient groundwater separation (e.g. 5 feet to 10 feet from bottom of leachfield to groundwater), and demonstrated unsaturated soil assimilative capacity. The high density of wastewater discharges in many of the commercial and residential areas of Malibu preclude adequate subsurface assimilative capacity. Available data indicates that site conditions in the coastal strips (high groundwater) and the highland residential area (fractured bedrock with the prevalent usage of seepage pits for disposal) do not warrant further reduction of nitrogen loads by soil treatment.

B. Because many calculations in the spreadsheet model were based on assumptions, a sensitivity analysis of the eventual nitrogen load estimates in response to the variation of key input parameters, such as flow rate, TN, and soil attenuation factor, is recommended.

Staff has conducted a sensitivity analysis to the spreadsheet model, but little impact was observed to the eventual nitrogen load estimates. Sensitivity analysis was made by changing the estimated flow rate and TN concentration in the spreadsheet model. All of the variations tried resulted in values much higher than the assigned TMDL load for septic systems in the lower Malibu Creek watershed).

C. Is it possible that seasonal effects are of importance to the average nitrogen load estimation in the Malibu Civic Center area?

Since most homes in the Malibu Civic Center area are owner occupied, little seasonal variation is expected on the wastewater flows from the single homes. Monitoring data large multi-family residences located in the area do not display seasonal significant variation. Wastewater flows from commercial sources do change by season as a function of the number of visitors. Staff observed slightly higher TN loads in the prime summer tourist season. Because the flow rate data in Tables 1 and 3 of Tech Memo #4 are annual averages over several years, seasonal variations were minimized.

D. Staff's judgment regarding the fate of nitrogen during on-site treatment and subsequent transport seems arbitrary. The discussion makes no distinction between ammonium ion absorption, which is both efficient and fast on soil particles, and *nitrification/de-nitrification reactions, which can lower the concentrations of available nitrogen forms and dramatically affect nitrogen transport in the subsurface.*

Because of variations of local site conditions, it is impractical to distinguish the form of nitrogen transport for all wastewater sources in the area. However, as detailed in Tech Memo #2, there are indications showing that natural attenuation (treatment of pollutants in soil) is not occurring in many areas of the Malibu Valley and the nearby Winter Canyon. There are numerous indications that the high density of subsurface wastewater discharges in the Malibu Civic Center Area has exceeded the natural assimilation capacity of the soil profiles. Because the goal of Tech Memo #4 is to determine the long term total nitrogen load of the Malibu Civic Center area to the Malibu Lagoon, the form of nitrogen transport should have little effect to the conclusion of the study. Both the numeric and spreadsheet models assume that total nitrogen is converted to nitrate after reaching surface waters.

E. Staff might comment on the form in which nitrogen is present in the Malibu Lagoon since this bears on the forms in which nitrogen is transferred from on-site disposal locations.

Malibu Lagoon is a unique aquatic system which opens to ocean during raining season and close during dry season. During dry seasons that nitrogen can be accumulated, significant breakthrough of nitrate or ammonia was not observed in the lagoon, but serious eutrophication has been observed. Staff assumes that total nitrogen in groundwater converts in the Lagoon to nitrate.

F. There are some inconsistencies between Tables 1 and 3. Since all the designed parameters are the same for all models, the calculated total nitrogen loads should be the same.

The inconsistencies between Tables 1 and 3 in Tech Memo #4 have been verified and corrected.

G. The non-point source nitrogen contributions to the Lagoon did not appear to have been considered. If these are available from the TMDL calculation, they should be considered as part of the total load.

The total load allocation of nitrogen in the Lagoon is 27 lbs/day. Because non-point sources have already been considered in the TMDL for Malibu Lagoon, they are not included in Tech Memo #4, which is to determine whether the total nitrogen load from OWDSs in the Malibu Civic Center area exceeds the 6 lbs/day allocation required in the TMDL for OWDSs sources. Details of total nitrogen load allocations from non-point sources in the larger Malibu Creek watershed are detailed in the TMDL (USEPA, 2003) and available on the Regional Board website at http:www.waterboards.ca.gov/losangeles.

H. How much a 6 lbs/day of nitrogen addition to the lagoon is likely to increase the available nitrogen levels in Malibu Lagoon?

An evaluation of nitrogen mass loading in Malibu Lagoon is given in Attachment 4-1 (by Dr. Lai) of Tech Memo #4. Figure 5 of Attachment 4-1 indicates that, assuming no other sources exist, a 6 lbs/day of total nitrogen load into the lagoon would bring the nitrogen concentration in the water from 0 to approximately 0.5 mg/L.

Editorial and grammatical suggestions have been followed as appropriate, but are not addressed here. A revised Tech Memo #4 that incorporates changes made in response to peer review comments is posted on the Regional Board website at http:www.waterboards.ca.gov/losangeles.

Staff would like to thank all three peer reviewers for their thoughtful review of Tech Memo #4 and providing their comments in a very timely, professional manner.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Dr. Robert Arnold
Chemical & Environmental Engineering
The University of Arizona
P.O. Box 210011
Tuscon, AZ 85721-0011

520-621-2591
520-621-6048 FAX

November 5, 2009

Memorandum

5 September 2009

To: Ms. Wendy Phillips; Chief, Groundwater Cleanup and Permitting Section, CA Regional Water Quality Control Board

From: Bob Arnold

Subject: Review of Regional Board Staff Technical Memorandum #4. Nitrogen loads from wastewater flowing into Malibu Lagoon.

I will first address the technical issues that were identified for peer review in attachments to your email note dated 28 August. Issues are taken in the order that you suggested.

1. The approach used to inventory wastewater discharges in the Malibu Civic Area (255,000 gallons per day). The flows inventoried fell into the following four classes:

(i) Large, permitted commercial enterprises with Waste Discharge Requirements (WDRs). A subset of these sources provide advanced wastewater treatment (undefined in the report) prior to effluent discharge. The other subset provides only septic treatment prior to discharge. For these sources there is a record of both wastewater volume generated and total nitrogen concentration (Kjeldahl, nitrate, nitrite) discharged to the environment.

(ii) Smaller permitted commercial sources, which also produced a record of wastewater volumes, but were not required to analyze for nitrogen forms in treated effluent. These sources seldom if ever provided advanced treatment prior to discharge.

(iii) Small businesses that were not regulated by the state and for which there was no official record of wastewater volume generated or probable total nitrogen concentration in treated waste.

(iv) Private residences, for which there was no record of wastewater flow or effluent quality.

Thus a complete inventory of the required wastewater volume generated required the authors to find or otherwise estimate the following information, generally from the tertiary sanitary engineering literature and/or the assumptions noted below:

- For dischargers in class (i) the volume flows and nitrogen levels provided all information necessary to calculate flows and respective nitrogen loads at points of discharge.
- For smaller, permitted commercial sources (class (ii), above) flow data were available, but nitrogen levels would depend on an assumption (see below) regarding total nitrogen level.
- Small business flows were estimated using information derived by staff regarding on-site population and business activity. Detailed information/methods for these steps are not described in Technical Memorandum No. 4.

- Flows from residences were estimated based on 100 gallons per day per residence bathroom.

There is very little to criticize in this approach to volume estimation. A few details or perhaps examples of the process by which flows were assigned to small, unpermitted businesses might provide a feel for this work. However, the magnitude of flow generated by this class of dischargers must have been fairly small and probably insignificant ---- making the quality of assumptions used or accuracy of related estimates almost irrelevant within the context of the overall exercise. To make this plain, it would be useful to organize the eventual flow information by class of discharger within each of the geographical sectors within the study area. It also seems possible that water use data, if uniformly available for small businesses could have been used to generate estimates of wastewater flows. It seems very unlikely that such an alternative approach, however, would have led to materially different results at the conclusion of the nitrogen analysis. In a sense, assumptions regarding domestic flows are the most critical, inasmuch as treated domestic wastewater is a major contributor to the eventual calculation of the nitrogen load to Malibu Lagoon. Again, water demand data might have been used to generate wastewater flow estimates.

In general, I am satisfied that no set of alternative (rational) assumptions would have materially improved the quality of the analysis to this point.

2. Methods for calculating nitrogen load contributions from individual OWDSs. Again relying on the four classes of dischargers within the Malibu Civic Area:

(i) Total nitrogen data were available for large, permitted commercial sources with WDRs. Again, there is no clear indication of which specific sources fell within this category in any of the summary tables, so that the efficiency of advanced wastewater treatment processes (unspecified) for nitrogen management cannot be determined from the Table 3 data.

(ii) It was assumed that the smaller, permitted, commercial sources produced an effluent that was similar to domestic effluent quality following septic treatment. The report indicates that some effort was undertaken to express effluent strength, including total nitrogen concentration as a function of the type of business practiced on site. Details and intermediate results from that work are not provided, however.

(iii) Site-specific information was used to anticipate total nitrogen concentration at unpermitted commercial facilities. Again, essentially no information is provided with which to illustrate the type of information collected, methodology for its conversion to nitrogen concentration or nitrogen load, and so forth.

(iv) The total nitrogen concentration in residential wastewater was estimated by assuming that the concentration of total nitrogen (as N) was a constant fraction (0.21) of the five-day biochemical oxygen demand. The correlation was taken from an exceptionally important sanitary engineering text and should be at least approximately correct.

I have the following reservations regarding the approach taken to estimation of nitrogen concentrations for the purpose of nitrogen load allocation at respective discharge points:

- Although the correlation between total nitrogen concentration and BOD_5 (0.21 mg/L as N per mg/L BOD_5 as O_2) may be accurate for domestic wastes, the justification for its use in this context is misleading. The authors contend that nitrogenous oxygen demand is a consistent contributor to BOD_5 (p. T4-4). In fact, the kinetics of biochemical oxygen demand may be dominated by carbonaceous oxygen demand over the first five days of the BOD measurement. This does not invalidate the approach taken, inasmuch as both total nitrogen and BOD_5 are useful indicators of the strength of a waste and are likely correlates in domestic wastewater. Since BOD_5 data were more broadly available than total nitrogen data, the method of estimation probably has merit. For those cases in which both BOD_5 and total nitrogen data are available, however, the authors should provide them --- to demonstrate the strength of the correlation.

- No attempt is made in the report to define "advanced" OWTS treatments. In the interest of defining the most significant sources of nitrogen load, the facilities that provide advanced treatment, the nature of the treatment provided and typical BOD_5 and total nitrogen removal efficiencies might be added to the report.

- The choice of BOD concentrations , absent data, and thus total nitrogen concentrations (21% of BOD_5) seems arbitrary:

Facility Type	BOD_5 (mg/L)	TN (mg/L as N)
Shopping centers with restaurants	800	160*
Small Offices	220	40
Schools		45-75**

* reduced to 80 mg/L to reflect frequent pumping of septic tanks at Malibu Country Mart.

** dependent on soil type and groundwater separation.

Nevertheless, any other assignment of values would be equally arbitrary and probably no more reasonable than the values chosen for the nitrogen loading models. At the end of the exercise, however, it isn't possible to determine which facilities were included in each class (large commercial, small commercial without water quality data, etc.) so it is not possible to reproduce the spreadsheet calculations from the data provided. Given that reviewers will be incapable of performing independent calculations, the authors might carry out their own sensitivity analysis-------to determine which parameters are the primary determinants of the eventual nitrogen load estimates. A good candidate for sensitivity analysis, for example, is the 80 mg/L (as N) total nitrogen concentration that is assumed for some of the commercial sources. Were this value actually 40 mg/L, would the outcome of the analysis change dramatically? The spreadsheet approach is well suited to make such repetitive calculations, and the results could be illuminating. This comment applies to several of the assumed parametric values.

- Various data elements are missing from table 1, page T4-20. Is there a reason for this?

- The apparent importance of residential contributions to regional nitrogen loading suggests that it may be important to distinguish between reported literature values (20, 45, 85 mg/L as N)---to make a selection that is appropriate for Malibu. If local data exist with which to make this distinction, they should be cited in the text. I failed to find data related to nitrogen levels in septic tank effluents, although staff suggested that measurements in septic tank effluent had been made. Absent data, the sensitivity of spreadsheet results to the assumed value should be determined.

- Finally, is it possible that seasonal effects are of importance to average nitrogen load estimation in the study area? No mention was made of variation in population or commercial activity in the Malibu study area. However, since estimated groundwater travel times to Malibu were sometimes on the order of decades, it is conceivable that winter occupancy rates and seasonal commerce might lower annual average nitrogen loading rates in a way that also lowers the average nitrogen load at the Malibu Lagoon. Since neither this study nor previous studies seem to have considered seasonal effects, it seems likely that they are unimportant in this context.

3. Division of the Malibu Civic Center area in hydrologic zones. There is clear justification for division of the study area into hydrologic zones. This seems like a very good way to account for substantial differences in fractional contributions of wastewaters to the Malibu Lagoon that arise from consideration of topography, water table contours and groundwater travel times to the lagoon. The breadth of both fractional contributions and estimates of groundwater travel times is a little unnerving. That is, travel times are held to vary from up to 50 years, for at least a portion of the wastewater discharged in sector I to less than one year for a portion of the flow that originates in sector II. The estimated fractions of discharged wastewater that reach the Malibu Lagoon range from 1% (Winter Canyon, main area sector IV, Sector V) to 95% (sector II much of sector III). The approach is sound, in my opinion, and potentially allows planners and engineers to discriminate geographically in making decisions regarding the importance of new sewerage to the quality of water in the Malibu Lagoon. That is, based on nitrogen considerations alone, it seems probable that new construction would be best deployed in sectors II, III and part of IV. The effects of that construction on lagoon water quality should be relatively rapid due to the short, estimated travel times. The staff's own spreadsheet model can be used to estimate fractional reductions in annual nitrogen load to Malibu Lagoon as consequence of several possible sewerage configurations. Staged construction and water quality response in the lagoon could then be used to avoid unnecessary extension of the sewage system.

I offer just a few comments in this area--- use of hydrological sectors, etc:

- Since water table contours are not provided in the report, readers are obliged to accept staff's opinion on gradients and groundwater flow directions. A contour map would undoubtedly lead those reviewing the document to the same conclusion that was reached by staff and would better ground the very significant assumptions about flow routing and contribution to Malibu Lagoon that are presented in the document. Such a contour map should be developed and included in the report if it is practical to do so.

- Where the selection of flow contribution by sector or sub-sector has an element of uncertainty, staff should examine the sensitivity of their general findings to the fraction adopted. The spreadsheet solution should make such an exercise accessible, and the results would likely show that staff findings are robust with respect to selection of sector-dependent factors governing respective fractions of on-site discharges that reach the lagoon.

- Judgment regarding the fate of nitrogen during on-site treatment and subsequent transport seems arbitrary. While estimated nitrogen losses may have been conservatively high, contributing to the strength of the staff's eventual findings and recommendations, it would be preferable to cite local data for the loss of total nitrogen during on-site treatment, and the discussion of nitrogen fate and transport following discharge is inadequate. That discussion makes no distinction between ammonium ion absorption, which is both efficient and fast on soil particles, and nitrification/de-nitrification reactions, which can lower the concentrations of available nitrogen forms and dramatically affect nitrogen transport in the subsurface. Furthermore, the availability of molecular oxygen in groundwaters affected by on-site discharges deserves attention since oxygen is required for nitrification. Finally, staff might comment on the form in which nitrogen is present in the Malibu Lagoon since this bears on the forms in which nitrogen is transferred from on-site disposal locations.

4. Model adjustment using new nitrogen load factors. I have nothing to say about the use of updated nitrogen load factors to adjust model results. This activity seems well justified and takes advantage of previous modeling work.

5. Other comments. I could make about a dozen grammatical suggestions but have not since this lies outside the scope of my review. I can send a marked up electronic version of the draft technical memorandum if you like.

In the end, I think that none of the comments offered here will materially alter the results of staff's analysis. Sensitivity analysis can be better used to show that analytical results are in fact robust with respect to tributary assumptions. Staff is well positioned to use their spreadsheet model for that purpose.

Although it goes beyond the limits of my review, I would like to know how much 6 lbs/day of nitrogen addition to the lagoon is likely to increase available nitrogen levels in Malibu Lagoon. To that end, what would be the incremental change in total nitrogen concentration in effluent from the Malibu Creek due to 6 lbs/day (as N) of supplemental nitrogen under some sort of critical flow condition?

Staff's analysis suggests that parts of the study area might be excluded from a sewer construction program since their collective on-site discharge contributes little or nothing to nitrogen levels in Malibu Lagoon. Staged construction would allow regulators to determine the effects of sewerage in areas that are the likeliest source of anthropogenic nitrogen in the lagoon, before extending sewer construction into the other geographic sectors of the study area.

In summary, staff's work is very well done. No set of alternative assumptions is likely to affect the general findings of the report. Sensitivity analysis could be used to demonstrate that point.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Dr. Jörg E. Drewes
DREWES ENVIRONMENTAL
798 Cressman Court
Golden, CO 80403
Phone 303-884-9746
E-mail: jdrewes@mines.edu

November 5, 2009

DREWES ENVIRONMENTAL
Professor Dr. Jörg E. Drewes

798 Cressman Court
Golden, CO 80403
Phone 303-884-9746
E-mail: jdrewes@mines.edu

September 10, 2009

California Regional Water Quality Control Board
Attn.: Wendy Phillips
Chief, Groundwater Permitting and Landfills Section
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Re: Peer Review of Technical Memorandum #4 in support of an amendment to the Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Mrs. Phillips,

Please find enclosed my review of the Technical Memorandum #4 "Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life" prepared by Toni Calloway, Orlando Gonzalez, and Dr. C.P Lai.

The review is providing responses to questions formulated in Attachment 2.

Please feel free to contact me if you have any further questions.

Thank you very much.

Sincerely,

Professor Jörg Drewes

Scientific Review Report of Technical Memorandum #4
Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life
by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E.

a. The approach used to compile an inventory of wastewater discharges from OWDSs in the Malibu Civic Center area, which staff estimates to total 255,000 gallons per day.

Wastewater discharges in the Malibu Civic Center area originate from commercial and residential sources. Flow data for commercial sources were available from monitoring reports for facilities permitted by the Regional Water Quality Control Board. Therefore, the flow estimate for commercial sources can be considered to be fairly accurate.
For residential sources, the number of individual residencies was determined using public records and aerial photographs that were used to confirm the number of residencies. This number can be considered as very accurate. Flow data for residential sources was based on the number of bedrooms and bathrooms at each residence, which served as a surrogate for the number of persons living at a given residence. A per capita water consumption of 100 gal/day was assumed referencing Table 2-9 (Metcalf and Eddy 1991). This table provides a range of "typical" water consumptions for individual residencies ranging from 40 to 90 gal/day and person (Metcalf & Eddy 1991). The latest edition of Metcalf and Eddy (2003) suggests a typical per capita water consumption of 74 gal/capita day without water conservation and 51.9 gal/capita day with water conservation. A study conducted by the Awwa Research Foundation on 1,100 households determined a per capita water consumption of 60.5 gpcd (Mayer et al. 1999). These more recent numbers would suggest that the assumption of 100 gal/capita day is too high and considering the national average should be corrected to 60-70 gal/capita day. Assuming 70 gal/capita day would reduce the total residential flow to 88,410 gpd and the total flow to 216,879 gpd.

Mayer, P.W., W.B. DeOreo, E.M. Optiz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson (1999). ***Residential End Uses of Water***, American Water Works Association Research Foundation, Denver, CO, 310 p.

b. The methodology used to calculate loads of nitrogen from wastewaters discharged from OWDSs in the Malibu Civic Center area; specifically, staff's interpretation of published literature and assumptions used to calculate nitrogen loads released from OWDSs for those discharges where real data were not available.

General:

- Using BOD concentrations to estimate total nitrogen concentrations when total nitrogen data is unavailable is in principal a reasonable approach. Where neither end-of-pipe nor septic tank effluent analyses were available, staff based the estimation of total nitrogen on typical total nitrogen concentrations reported in the published literature on domestic wastewater composition. In section i) (Commercial Wastewater), the authors refer to two key sources

(Crites and Tchobanoglous 1998 and Metcalf and Eddy 1991) that have been considered regarding ranges of concentrations in typical untreated domestic wastewater. The authors proposed a TN/BOD ratio of 0.2.

The reviewer notes that these particular sources did not distinguish between water characteristics of single sources and raw sewage collected in a centralized sewer system. The wastewater discharged in the Malibu Civic Center area originates from single sources, which have a different make-up regarding organic matter and nitrogen than raw sewage collected in a centralized system. Thus, more appropriate references should be considered to provide a more accurate representation of single source waste streams. A very useful reference that the authors might want to consider is a recent research report published by the Water Environment Research Foundation (***Lowe, K., et al. 2007, Influent Constituent Characteristics of the Modern Waste Stream from Single Sources: Literature Review. Water Environment Research Foundation (WERF), Alexandria, VA***). Based on a comprehensive literature review of waste streams from single sources, findings of this report suggest the following median concentration for septic tank effluents:

Source	BOD (mg/L)	TN (mg/L N)	TN/BOD ratio
Single source	156	55.4	0.36
Multiple sources	184	46	0.25
Food	561	86.5	0.15
Non-medical	244	84	0.344

These results would suggest that a TN/BOD ratio of 0.3 might be more appropriate for single domestic as well as commercial sources (non-medical) than the ratio of 0.2 considered by the authors.

In addition, the authors considered "typical untreated domestic wastewater". Since in this case, septic tank effluents contribute to groundwater contamination, a water quality leaving the tank rather entering a tank should be considered. While septic tanks achieve little to none nitrogen removal, the EPA Onsite Wastewater Treatment Manual (2002) reports 30 to 50 percent of BOD is removed whereas Lowe et al. (2007) reported 55 percent removal during septic tank treatment. In both cases, BOD changes occurring during septic tank treatment will result in shifting the TN/BOD ratio to higher numbers.

Since this ratio was used in the nitrogen load spreadsheet, that was not available to the reviewer, in cases where no "end-of-pipe" total nitrogen concentrations were available, which percentage was also not available, the reviewer cannot assess whether changing the TN/BOD ratio from 0.2 to 0.3 would have a significant effect.

- p. T4-5, third paragraph. "For commercial dischargers such as small offices where we have no data, we choose a low BOD of 220 mg/L, and estimated the TN to be 40 mg/L."

What is the basis for this estimation? As mentioned above, the authors might want to consider findings reported in Lowe et al. (2007). Findings reported in this study would suggest that the BOD concentration for "small offices" is matching the median concentration of 244 mg/L for non-medical sources, but the total nitrogen concentration is only 50 percent of what was determined for non-medical sources (i.e., 84 mg/L N). Thus, the release of nitrogen from these sources is potentially significantly underestimated.

- p. T4-5, fourth paragraph, last sentence. What is the basis (reference?) for reducing estimated total nitrogen concentrations depending on soil profile and groundwater separation? Why is credit given to subsurface treatment where no credit is given to BOD during septic tank treatment?

- The estimation of the total commercial flow seems reasonable and supported by actual flow data.

- In section ii) (Residential Wastewater), the underlying assumption to estimate the residential flow is 100 gal/capita day. Please see discussion under a.), but the water consumption based on more recent studies would suggest 60-70 gal/capita day.
The estimation of nitrogen concentrations in domestic wastewater is referencing Metcalf and Eddy (1991) with three values (20, 40 and 85 mg/L) for weak, medium and strong wastewater. In the most recent edition of Metcalf and Eddy (2003) these values were revised to 20, 40 and 70 mg/L N.
The recent study by Lowe et al. (2007) reported a median total nitrogen concentration for residential single sources of 63 mg/L N for raw sewage and 55.4 mg/L N for septic effluent, respectively. These values provide support for the total nitrogen concentration of 60 mg/L for septic tank influent proposed by the Regional Board staff in this memorandum.
Although the staff acknowledged that septic tank systems are limited in their ability to remove nitrogen, which is supported by multiple studies (EPA 2002, Lowe et al. 2007), credit was given to OWDS treatment and the estimated total nitrogen concentration of septic tank effluents in the Malibu Civic Center area was reduced from 60 to 45 mg/L N. The basis for this reduction is weak at best.

- Summary of Total Nitrogen Loading from Commercial and Residential Sites
The estimation of total nitrogen releases from commercial sources could be affected by the used TN/BOD ratio of 0.2, which was suggested to be closer to 0.3. For the residential sources, considering a 70 gal/capita day water consumption and nitrogen concentration of 45 mg/L N, the nitrogen load would have been reduced to 12,118 lbs/year or 33.2 lbs/day. Considering the lower water consumption (70 gpcd) and 60 mg/L N, would reduce the total nitrogen loading from 17,311 lbs/year as stated in the report to 16,157 lbs/year or 44.3 lbs/day. This number is close to the estimate of 47.4 lbs/day provided by the Regional Board staff.

<u>Specifics:</u>
- p. T4-4, first subheading. BOD is defined as "biochemical oxygen demand", not "biological oxygen demand" as stated. Please revise.

- p. T4-5, first paragraph. "...TN/BOD ratio found in the above popular wastewater textbooks." The term "popular" doesn't buy credibility and I'd suggest "peer-reviewed", which represents a

better term. Regardless, the author might want to consider other references (see discussion above) that might be more suitable.
- p. T4-6, last paragraph, third sentence. "Using reported or estimated using wastewater…". Typo, deleted "using".

U.S. EPA (2002). *Onsite Wastewater Treatment Systems Manual*. Report No. 625/R-00/008. U.S. Environmental Protection Agency, Cincinnati, OH.

c. Staff's characterization of groundwater flow regimes in the Malibu Civic Center area into five hydrogeologic sectors, and staff's application of the nitrogen loads (calculated from #2 above) into a 'spreadsheet' model that estimates attenuation of nitrogen loads released from OWDSs and transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon) for each hydrogeologic sector.

The proposed characterization of groundwater flow regimes into five hydrogeologic sectors seems reasonable and is well supported. The number of residencies/sources in these sectors is well known. The estimated flow of wastewater in each section could potentially be revised considering a lower per capita water consumption (60-70 gpcd) as discussed above. The same holds true for the considered total nitrogen concentrations for individual sources, which could be adjusted from 45 mg/L to 60 mg/L N.
The assumed total nitrogen load reduction factors by "soil treatment" for commercial sites is reasonable. Given that little is known about site specific conditions of residential sites, the assumption that no soil treatment is occurring is appropriate.

d. Staff's use of the updated nitrogen loads released from OWDSs (calculated from #2 above) to adjust (update) estimates of nitrogen transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon), using a relationship already established by a groundwater flow and transport model (which is already accepted by stakeholders in the community).

Besides the comments provided above regarding flow estimation and nitrogen loading from both commercial and residential sites, the use of updated nitrogen loads released from OWDSs to adjust estimates of nitrogen transported to Malibu Lagoon seems reasonable. The adjustments made in these calculations are appropriate (concentrations might change and discharge volumes, see comments above). The only aspect that is somewhat inconsistent is the assignment of a "Leach Field Reduction". What constitutes a reduction of 10 percent vs. 20 percent? In Sector 3, sites with a soil type "sand, silt & clay" and depth to groundwater of 10 or >10 were assigned reduction credits between 0 and 20 percent!?

Overarching questions:

(a) In reading Tech Memos #3 and #4, are there any additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

Regarding Tech Memo #4, there are not additional scientific issues that need to be addressed.

(b) Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices?

Regarding Tech Memo #4, with the exception of comments provided above regarding flow estimation and nitrogen loads, the conclusions presented in this Tech Memo are based on sound scientific knowledge, methods, and practices.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Dr. Joann Silverstein
Dept. Civil, Environmental & Architectural Engineering
University of Colorado
Boulder, CO 80309-0428 USA
tel: (303) 492-7211
fax: (303) 492-7317

November 5, 2009

Peer Review of Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life, by Tony Calloway, P.G., Orlando Gonzalez, and Dr. C.P. Lai, P.E.

JoAnn Silverstein, Ph.D., P.E.
September 12, 2009

<u>Determination for issues requested in Attachment 2: Description of Scientific Issues to be addressed by Peer Review.</u>

a. *Approach used to compile an inventory of wastewater discharges from OWDSs in the Malibu Civic Center area, which staff estimates to total 255,000 gallons per day.*

Residential wastewater flow was estimated to be 100 gal/toilet/day, which is assumed to represent the wastewater generated by one person. The 349 residences had 1,263 bathrooms producing the estimate in Table 1 of 126,300 gal/day of residential wastewater. The rationale for the one person per toilet equivalent is not given. However, accepting that equivalent, 100 gallons per capita per day (gpcd) is high for households of more than two persons. A more recent text estimate for domestic wastewater flow rates for households of 3 – 4 persons is 41-71 gpcd (Metcalf and Eddy, 2003). The Onsite Wastewater Treatment Systems Manual (USEPA, 2002) reports estimates of residential wastewater ranged between 50 and 70 gpcd for homes built before 1994. For newer homes with water-saving fixtures, the reported range of wastewater flow rates was 40 – 60 gpcd. The US Census Bureau estimated that the average household size (1998) was 2.7 people per residence. With 349 residences with on-site systems, the population equivalent based on Census data would be 942, and the corresponding wastewater flow rate using the more conservative EPA flow rate range (pre-1994 homes) would be 47,000 to 66,000 gal/day, approximately half or less than the flow rate estimated in Table 1: 126,300 gal/day. Another method to estimate wastewater flow is to use the number of bedrooms, and assume 1 – 1.5 people/bed. Since the number of bathrooms and bedrooms are nearly identical in Malibu, this would produce a population range of 1,263 to 1,894, and a flow rate range, using the EPA per capita flow rate range of 63,000 to 133,000 gpcd. Only the most conservative assumptions of 1.5 persons per bedroom (or bathroom) and 70 gpcd wastewater flow produce flow rate close to the value in Table 1. For one person per bathroom (and bedroom), at the high per capita flow rate, the estimated residential flow is 88,400, 30% lower than the Table 1 value. The high residential wastewater flow rate estimated in Table 1 is not well justified given estimation methods reported in the literature. Consideration should be given to characterizing the uncertainty in the residential wastewater flow estimates, including reporting values with fewer significant figures than 4 – 6 significant figures in Table 1 entries.

For commercial properties, flow data were available for permitted sites that were assumed to be representative of average flow rates. Flow data for unpermitted sites was estimated but the method used was not reported. For example, the basis for 400 gal/day for small commercial facilities should be given. Also, it would be useful to indicate in Table 1 which commercial facilities were unpermitted. In addition, the percent of the commercial flow estimate of 128,469 gal/day that was estimated would provide a better indication of the uncertainty in the commercial flow rate estimates.

b. *The methodology use to calculate loads of nitrogen from wastewaters discharged from OWDS's in the Malibu Civic Center area; specifically staff's interpretation of published literature and assumptions use to calculate nitrogen loads released from OWSDS's for those discharges where real data were not available.*

Residential nitrogen loads were estimated assuming that wastewater discharged from septic tanks contained 45 mg/L total nitrogen. Estimates of residential septic tank effluent (STE) nitrogen concentration range from 40 to 100 mg/L, depending on influent water quality, tank hydraulic and solids residence times (USEPA, 2002). The total nitrogen mass loading from residential on-site systems was estimated to be 47.429 lb/day (too many significant figures!), based on the estimated residential flow rate of 126,300 gal/day and average STE total nitrogen of 45 mg/L. As a check, the estimate of 0.03 lb-TKN/cap/day (Metcalf and Eddy, 2003) and the population estimate based on bathroom number were used to calculate a total nitrogen loading from residences in the study area: to be 38 lb/day. Assuming no attenuation of nitrogen in a septic tank, this is ~19% lower than the estimated daily loading rate from residences of 47 lb/day in Table 1. Most literature reports indicate that almost 90% of the nitrogen in STE is in the form of ammonium. Removal of nitrogen in a subsurface wastewater infiltration system (SWIS) or leach field occurs by a combination of sorption, biomass uptake, and nitrification-denitrification and was estimated in the groundwater loading section of Technical Memorandum #4, as summarized in Table 3.

Eight businesses served by package plants appeared to be the only commercial discharges where effluent total nitrogen data were available. These plants constituted 46% of the estimated commercial flow (59,000 gal/day) but had consistently lower effluent nitrogen than other commercial discharges, constituting 8 lb-TN/day, which was only 19% of the daily total nitrogen load in the study areas (42 lb/day).

Commercial septic tank effluent not reported was estimated, typically as a fraction of BOD, the second of two key assumptions (page T4-5, paragraph 1). (By the way, the callout for Table 2 in this paragraph appears to be wrong. The nitrogen loading spreadsheet is Table 1.) It is widely recognized that some commercial facilities, particularly restaurants, have very high BOD concentrations compared with residential wastewater. However, the 0.18 – 0.21 TN:BOD ratio from the literature which was used to estimate the total nitrogen concentration in commercial wastewater effluent was based on <u>residential</u> wastewater characterization, where as much as 78% of the nitrogen comes from toilet waste (urea) (USEPA, 2003, Table 3.8). In restaurants, the excess BOD probably comes from food waste, oil, and grease, which should have a generally lower TN:BOD ratio. One study (Converse et al, 1984) found restaurant that septic tank effluent total nitrogen ranged from 30 to 82, with a flow-weighted mean of 57 mg/L and an average TN:BOD ratio of 15.6 g-N/g-BOD_5. This is a concern in the reliability of the commercial wastewater nitrogen loading estimate. Nine commercial discharges had estimated nitrogen concentrations $\geq$ 75 mg/L and were 27% of the commercial wastewater flow. Together the nitrogen discharged from them was 9,000 lb-TN/year, which was 58% of the total commercial nitrogen loading estimate. The effluent nitrogen concentration in just one of these, (Malibu Inn and Restaurant) was estimated to be 110 mg/L at a flow rate of 6,200 gal/day, which means that the discharge from this one facility constituted over 13% of the total commercial nitrogen load. Given the impact of the commercial discharges with high nitrogen on the total loading estimate, it is advisable that samples be taken verify the high nitrogen discharge numbers, particularly if the nitrogen concentration estimates were based on the TN:BOD ratio characteristic of residential wastewater. Moreover, characterization of the uncertainty in these estimates, incorporating better values of restaurant wastewater from the literature, and perhaps analysis of the sensitivity of the total nitrogen loading rate to estimated high nitrogen loading rates should be done.

c. *Staff's characterization of groundwater flow regimes in the Malibu Civic Center area into five hydrogeologic sectors, and staff's application of the nitrogen loads (calculated from #2 above [should be b?[) into a spreadsheet model that estimates attenuation of nitrogen loads released from OWDS's and transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon) for each hydrogeologic sector.*

Division of the region into topographic and hydrogeologic sectors to calculate groundwater flow and associated nitrogen loading rates to the Malibu Lagoon, summarized in Table 3, is a good approach. Estimates of attenuation of nitrogen in SWIS's were very conservative, from 0 to 20%; whereas typical estimates in the literature ranged from 10 – 40% based on soil type. Given that most of the soil in the region was high permeability sand and silt, this may be reasonable. It appeared that the 0% removal was applied when the depth to the ground water table was < 5 ft, regardless of soil characteristics. The other assumption was that nitrate could be used as a surrogate for total nitrogen discharged to the groundwater. This assumes significant nitrification (bacterial oxidation of ammonia to nitrate) in the unsaturated zone, which is supported by the literature. In one case study, the average nitrate concentration in a fine sand SWIS peaked at 21.6 mg/L NO_3-N at a depth of 0.6 m (2 ft), but was still high, 13 mg/L NO_3-N, after percolating to a depth of 1.2 m (4 ft), although there was clearly some attenuation, probably by denitrification, even in the sandy soil (USEPA, 2002). Particularly in wastewater SWIS systems, there will be residual organic matter in the soil that can be used by denitrifying bacteria to reduce nitrate to N_2 gas, so the zero attenuation factor for shallow groundwater table may be too conservative. As with the nitrogen loading estimates, it would be useful to perform a sensitivity analysis for SWIS (leach field) attenuation estimates. Also, if there are monitoring wells near leach fields, nitrate concentrations could be measured to verify these estimates.

d. *Staff's use of the updated nitrogen loads released from OWDS's (calculated from #2 [b?] above) to adjust (update) estimates of nitrogen transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon), using a relationship already established by a groundwater flow and transport model (which is already accepted by stakeholders in the community).*

The staff's estimate of total nitrogen loading to Malibu Lagoon using the spreadsheet model (Table 4) was 36 lb/day with 38% of the TN mass loading from OWDS reaching the Lagoon, compared with 32% in the numeric model. There is an inconsistency between the spreadsheet column estimate in Table 4 and Table 1 in Attachment 4-1 (page T4-41). In the attachment Table 1, the ratio is given as 40%, with an associated mass loading of 35.7 lb/day. This is a small discrepancy, and may just be rounding difference. However since all the input data are the same, the two tables should be consistent for the spreadsheet estimate. An overall concern is that the rationale for increased commercial loading was not clear, either in section 2.2 of Attachment 4-1 or in Section 3 of the Report (page 4-13-14). Commercial flows increased, but this was captured in the nitrogen loading estimates. The possibility of exceeding soil uptake capacity for nitrogen removal was mentioned in section 2.2 of Attachment 4-1, but there was no indication of how this resulted in an increase in the fraction of the nitrogen reaching Malibu Lagoon from 32 to 38% (or 40% in Attachment Table 1).

The CSTR model used to compare the estimate mass loading to measured nitrogen concentrations was interesting and appears to support the higher estimates of nitrogen loading to the Lagoon. However, the non-point source nitrogen contributions to the Lagoon did not appear to have been factored in. If these are available from the TMDL calculation, they should be considered as part of the total load.

General comments.

Check document for typos, grammatical errors and erroneous callouts. Examples:
p. T4-2, para. 4, line 5: "conservation" should be conservative.
p. T4-3, last line: "facility" should be facilities.
p. T4-5, para 4, line 1 should read: For wastewater generated by commercial facilities…
p T4-6, para 1, line 3 should read: Since 2001, the inventory of commercial properties (delete "on")
p. T4-6, para 5, line 4 should read: Using reported or estimated wastewater (delete second "using")
page T4-7, section Assumptions for Residential Flow and Total Nitrogen Concentration. The estimate of 100 gallons per day per bathroom is for water use, not wastewater generation. You appear to have made the assumption that wastewater generation = water use. This is generally not the case, and Metcalf and Eddy is not correctly cited. (See comments in part a). Also, instead of using the unit 100 gallons per person, the usual unit is gallons per capita per day (gpcd).

Use appropriate significant figures, especially in Tables. Calculated values with 4-6 significant figures do not reflect the input information.

Overarching questions

(a) The scientific basis for the proposed rule, regarding nitrogen discharges from OWDS's to Malibu Lagoon includes estimates not based on site data but literature values, some of which can be questioned (see specific comments in parts a, b, and c above). Overall, a higher scientific standard would be achieved by better characterization of the uncertainty in the estimates, careful use the most recent literature, and analysis of the sensitivity of the results to variation of key input parameters such as flow rates, effluent nitrogen concentrations from OWDS's, and soil attenuation factors.
(b) Even with the concerns above, the general approach and methods used in Technical Memorandum #4 incorporate sound scientific and engineering principles. Adjustments based on less conservative assumptions could lower the OWDS nitrogen loading rate, even by as much as one-third. However, even the lowered loading rate would still far exceed the TMDL, and the conclusion in the Memorandum that the 6 lb/day maximum loading rate for wastewater nitrogen will not being achieved using OWDS's is reasonable and justified.

References

Converse, J.C., R.L. Siegrist, and D.L. Anderson, Onsite Treatment and Disposal of Restaurant Wastewater, Report 10.13, Small Scale Waste Management Project, Univ. Wisconsin, 1984.

Metcalf and Eddy, Wastewater Engineering Treatment and Reuse, 4th Ed., McGraw-Hill, NY. 2003.

USEPA, National Risk Management Research Laboratory, Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Washington, DC. 2002.